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PROCEEDINGS

of the

TENTH ANNUAL MEETING

HELD AT

PITTSBURG, PA., JUNE [illegible]

Volume X

And Index, Vols. I-X

EDITED BY

ROBERT FLETCHER CALVIN M. WOODWARD CLARENCE A. WALDO

Committee

NEW YORK
ENGINEERING NEWS PUBLISHING CO
220 Broadway
1902

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Society
FOR THE
Promotion of Engineering Education

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ROBERT FLETCHER CALVIN M. WOODWARD CLARENCE A. WALDO

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LANCASTER, PA.

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1902-1903.

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*This list gives only the elective members. The officers (p. v) and the past presidents (p. xxix) are members of the Council *ex officiis*.

LIST OF MEMBERS.

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
ADAMS, COMFORT A., JR... Cambridge, Mass	Assistant Professor of Electrical Engineering, Harvard University......	1894
ALDERSON, VICTOR C....... Chicago, Ill.	Dean of the College of Engineering, Armour Institute of Technology....	1900
ALDRICH, WILLIAM S...... Potsdam, N. Y.	Director, Clarkson School of Technology	1893
ALLEN, C. FRANK......... Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
ANDERSON, F. PAUL....... Lexington, Ky.	Dean of the School of Mechanical and Electrical Engineering, Professor of Mechanical Engineering, State College of Kentucky...............	1894
ANDERSON, DOUGLAS S.... New Orleans, La.	Associate Professor of Electrical Engineering, Tulane University.........	1900
ANTHONY, GARDNER C..... Tufts College, Mass.	Professor of Technical Drawing and Dean of the Department of Engineering, Tufts College.................	1896
ARNOLD, BION J........... Chicago, Ill.	Consulting Electrical Engineer, 1541 Marquette Bldg..............	1896
AYER, ARTHUR W......... 35th St. and Gray's Ferry Road, Philadelphia, Pa.	Mechanical Engineer for Harrison Bros. and Co., Inc................	1894
AYERS, BROWN............ New Orleans, La.	Professor of Physics and Electrical Engineering, Dean of College of Technology, Tulane University......	1898
BAKER, IRA O............. Champaign, Ill.	Professor of Civil Engineering, University of Illinois..............	1893
BARNEY, SAMUEL E., JR... New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University...............	1894
BARR, JOHN H............ 39 East Avenue, Ithaca, N. Y.	Professor of Machine Design, Sibley College, Cornell University.........	1902
BARRACLOUGH, S. HENRY.. Sydney, N. S. W., Australia.	Acting Professor of Engineering, Russell School of Engineering, University of Sydney..............	1900

Name and Address.	Title.	Date of Membership.
Barrows, Harold K....... 32 West Prospect St., Burlington, Vt.	Assistant Professor of Civil Engineering, University of Vermont........	1902
Benjamin, Charles H..... Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science......	1893
Berg, Walter G........... 261 West 52d St. New York City.	Chief Engineer, Lehigh Valley Railroad Co..........................	1901
Beyer, Samuel W......... Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State College........	1899
Beyer, T. Raymond....... 119 Maplewood Ave., Germantown, Pa.	Civil Engineer.....................	1895
Bissell, George W........ Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College................	1894
Bixby, Wm. H............. Jones Bldg., Detroit, Mich.	Major Corps of Engineers, U. S. Army, U. S. Engineer Office................	1898
Blanchard, Arthur H..... Brown University, Providence, R. I.	Instructor in Civil Engineering, Brown University	1902
Bovey, Henry T........... Montreal, Que.	Dean of the Faculty of Applied Science, Professor of Civil Engineering and Applied Mechanics, McGill University	1893
Bradford, Joseph N....... Columbus, Ohio.	Professor of Architecture and Drawing, Ohio State University.........	1896
Brady, Frank W.......... Scranton, Pa.	Engineering Text-book Writer for the International Correspondence School.	1899
Bray, Charles D......... Tufts College, Mass.	Professor of Civil and Mechanical Engineering, Tufts College............	1894
Breckenridge, Lester P.... Urbana, Ill.	Professor of Mechanical Engineering, University of Illinois..............	1893
Brill, George M.......... 1143–1144 Marquette B'lding, Chicago, Ill.	Consulting Engineer................	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BROOKE, WILLIAM E....... Minneapolis, Minn.	Instructor in Engineering Mathematics, University of Minnesota....	1902
BROOKS, JOHN P.......... Lexington, Ky.	Professor of Civil Engineering, State College of Kentucky..........	1898
BROOKS, MORGAN.......... Urbana, Ill.	Professor of Electrical Engineering, University of Illinois..............	1899
BROWN, HAROLD W........ Newark, Del.	Associate Professor of Mechanical and Electrical Engineering, Delaware College	1902
BROWNE, WM. HAND, JR.... 431 Beech St., Richmond Hill, N. Y.	Technical Editor of the Electrical Review, New York..................	1899
BRUEGEL, A. THEODORE..... 3728 Walnut St., Philadelphia, Pa.	Professor of Mechanical Engineering, Drexel Institute	1900
BRYDONE-JACK, ERNEST E.. Fredericton, New Brunswick.	Dean of the Engineering Faculty, University of New Brunswick..........	1902
BULL, STORM............. Madison, Wis.	Professor of Steam Engineering, University of Wisconsin............	1893
BURGESS, CHARLES F...... Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin..	1896
BURR, WILLIAM H......... New York, N. Y.	Professor of Civil Engineering, Columbia University...............	1893
BURRAGE, SEVERANCE...... Lafayette, Ind.	Instructor in Sanitary Science, Purdue University.................	1898
CALDWELL, FRANCIS C..... Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University............	1897
CARHART, DANIEL,........ Wilkinsburg, Allegheny, Pa.	Professor of Civil Engineering and Dean of the Faculty, Western University of Pennsylvania............	1902
CARPENTER, LOUIS G...... Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
CARPENTER, ROLLA C. Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University	1893
CARSON, WILLIAM W. Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee	1894
CHANDLER, CLARENCE A. 12 Westland St., Worcester, Mass.	Superintendent of the Washburn Shops	1902
CHASE, CHARLES H. 37 Lincoln St., Stoneham, Mass.	Assistant Professor of Steam Engineering, Tufts College	1900
CHATBURN, GEORGE R. Lincoln, Neb.	Adjunct Professor of Civil Engineering, University of Nebraska	1899
CHRISTY, SAMUEL B. Berkeley, Cal.	Professor of Mining and Metallurgy, University of California	1893
COLBURN, GEORGE L. Rochester, N. Y.	Instructor in Machine Work and Mechanical Drawing, Rochester Athaneum and Mechanics Institute	1901
COLBY, IRVING A. Durham, N. H.	Instructor in Wood Working, New Hampshire College of Agriculture, and the Mechanic Arts	1902
CONSTANT, FRANK H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
COOLEY, MORTIMER E. Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan	1893
CORTHELL, ELMER L. 1 Nassau St., New York City.	Civil Engineer	1895
CRANDALL, CHARLES L. Ithaca, N. Y.	Professor of Railroad Engineering and Geodesy, Cornell University	1893
CREIGHTON, W. H. P. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
CRENSHAW, BOLLING H. Auburn, Ala.	Associate Professor of Mathematics, Alabama Polytechnic Institute	1894
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Dean, Arthur D. Springfield, Mass.	First Assistant, Mechanic Arts High School	1901
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Denton, James E. Hoboken, N. J.	Professor of Mechanical Engineering and Shopwork, Stevens Institute of Technology	1893
Denton, Frederick W. Houghton, Mich.	Superintendent, Winona Mine	1894
Diemer, Hugo Lawrence, Kans.	Associate Professor of Mechanical Engineering, University of Kansas..	1902
Drown, Thomas M. South Bethlehem, Pa.	President, Lehigh University	1895
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
Dudley, Charles B. Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1894
Duncan, Lindsay Ithaca, N. Y.	Instructor in Civil Engineering, Cornell University	1901
Durand, William F. Ithaca, N. Y.	Professor of Marine Engineering, Cornell University	1899
Eddy, Henry T. Minneapolis, Minn.	Professor of Engineering and Mechanics, University of Minnesota	1893
Emory, Frederick L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
Engler, Edmund A. Worcester, Mass.	President, Worcester Polytechnic Institute	1897
Esty, William South Bethlehem, Pa.	Assistant Professor of Electrical Engineering, Lehigh University	1898
Faig, John T. Lexington, Ky.	Professor of Machine Design, State College of Kentucky	1899
Farwell, Elmer S. 30 Broad Street, New York.	Steam Engineer, International Paper Co	1895

Name and Address.	Title.	Date of Membership.
Fernald, Robert H. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1899
Fisher, James, Jr. Houghton, Mich.	Instructor in Mathematics and Physics, Michigan College of Mines	1899
Flather, John J. Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota	1893
Fletcher, Robert Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College	1894
Flint, Walter Port Deposit, Md.	Supervising Engineer, The Jacob Tome Institute	1898
Foss, Fred. E. State College, Pa.	Professor of Civil Engineering, Pennsylvania State College	1893
Frankforter, George B. Minneapolis, Minn.	Professor of Chemistry, University of Minnesota	1897
Franklin, William S. Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1900
Freedman, William H. 222 South Union St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont.	1902
French, Arthur W. Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute	1900
French, Thomas E. Columbus, O.	Associate Professor of Architecture and Drawing, Ohio State University.	1899
Frink, Fred. G. Ann Arbor, Mich.	Instructor in Civil Engineering, University of Michigan	1902
Fuertes, Estevan A. Ithaca, N. Y.	Director and Dean of College of Civil Engineering, Cornell University	1894
Fullan, M. Thomas J. Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute	1897
Fuller, Almon H. University Station, Seattle, Wash.	Professor of Civil Engineering, University of Washington	1901
Galbraith, John Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science	1893

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GIESECKE, F. E. College Station, Tex.	Professor of Drawing, Texas Agricultural and Mechanical College	1893
GILL, JAMES H. Bozeman, Mont.	Assistant Professor of Mechanical Practice, Montana College of Agriculture and Mechanic Arts	1896
GOLDSBOROUGH, WINDER E. Lafayette, Ind.	Professor of Electrical Engineering, Director of the Electrical Laboratory, Purdue University	1897
GOODENOUGH, GEORGE A. Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois	1900
GOSS, WILLIAM F. M. Lafayette, Ind.	Professor of Experimental Engineering and Dean of Schools of Engineering, Purdue University	1893
GRAY, THOMAS Terre Haute, Ind.	Professor of Dynamic Engineering, Rose Polytechnic Institute	1895
GRIFFIN, CHARLES L. Syracuse, N. Y.	Professor of Mechanical Engineering, Syracuse University	1900
GROAT, BENJAMIN F. Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, School of Mines, University of Minnesota	1899
GROVER, NATHAN C. Orono, Me.	Professor of Civil Engineering, University of Maine	1894
HALSTED, GEORGE B. Austin, Tex.	Professor of Mathematics, University of Texas	1899
HAMLIN, GEORGE H. Orono, Me.	Civil Engineer	1895
HARPER, JOSEPH D. St. Louis, Mo.	Manager of Machinery Department, Fairbanks, Morse & Co.	1899
HARRIS, ABRAM W. Port Deposit, Md.	Director of The Jacob Tome Institute.	1897
HARRIS, ELMO G. Philadelphia, Pa.	Associate Professor of Civil Engineering, University of Pennsylvania	1894
HATT, WILLIAM K. Lafayette, Ind.	Professor of Applied Mechanics, Purdue University	1895

Name and Address.	Title.	Date of Membership.
HAVILAND, EDWIN, JR..... Potsdam, N. Y.	Professor of Mathematics and Civil Engineering, Clarkson School of Technology	1902
HAWES, JOSEPH H......... Durham, N. H.	Associate Professor of Drawing, New Hampshire College of Agriculture and the Mechanic Arts........	1900
HAYNES, ARTHUR E........ Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota............	1895
HAZEN, JOHN V........... Hanover, N. H.	Professor of Civil Engineering, Dartmouth College................	1896
HIBBARD, H. WADE........ Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
HILL, JOHN E............ Providence, R. I.	Professor of Civil Engineering, Brown University.................	1894
HITCHCOCK, EMBURY A.... Columbus, Ohio.	Professor of Experimental Engineering, Ohio State University.........	1899
HOAG, WILLIAM R........ Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota............	1893
HOFMAN, HEINRICH O...... Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology.......	1894
HOLDEN, CHARLES A....... Hanover, N. H.	Instructor in Civil Engineering and Mathematics, Thayer School of Civil Engineering, Dartmouth College....	1901
HOLLIS, IRA N............ Cambridge, Mass.	Professor of Engineering, Harvard University................	1894
HOOD, OZNI P............ Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
HOSKINS, LEANDER M...... Stanford University, California.	Professor of Applied Mathematics, Leland Stanford Junior University..	1893
HOWE, CHARLES S......... Cleveland, Ohio.	Professor of Mathematics and Astronomy, Case School of Applied Science.	1902
HOWE, MALVERD A........ Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute..........	1894

Name and Address.	Title.	Date of Membership.
Hume, Alfred University, Miss.	Professor of Mathematics and Acting Professor of Civil Engineering, University of Mississippi	1894
Humphreys, David C. Lexington, Va.	Professor of Civil Engineering, Washington and Lee University	1893
Hutton, Frederick R. New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1894
Ives, Howard C. Worcester, Mass.	Instructor in Civil Engineering, Worcester Polytechnic Institute	1901
Jackson, Dugald C. Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin	1893
Jackson, John P. State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College	1894
Jacobus, D. S. Hoboken, N. J.	Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology	1893
Jacoby, Henry S. Ithaca, N. Y.	Professor of Bridge Engineering and Graphics, Cornell University	1894
Jett, Carter C. 3200 West Ave., Newport News, Va.	Draughtsman Newport News Shipbuilding and Dry-dock Co.	1902
Johnson, Lewis J. Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University	1898
Jones, Clement R. Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University	1895
Jones, Forrest R. Worcester, Mass.	Professor of Machine Design, Worcester Polytechnic Institute	1893
Kavanaugh, William H. Minneapolis, Minn.	Assistant Professor of Mechanical Engineering, in charge of Experimental Engineering, University of Minnesota	1902
Kay, Edgar B. Ithaca, N. Y.	Instructor in Civil Engineering, Cornell University	1898

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
KENT, WILLIAM Passaic, N. J.	Consulting Engineer, Associate Editor of 'Engineering News,' New York City	1894
KERR, CHARLES V. 3321 Armour Ave., Chicago, Ill.	Professor of Mechanical Engineering, Armour Institute of Technology	1902
KIDWELL, EDGAR Room 607, 330 Market St., San Francisco, Cal.	Consulting Engineer	1896
KINEALY, J. H. Boston, Mass.	Consulting Mechanical Engineer	1893
KINGSBURY, ALBERT Worcester, Mass.	Professor of Applied Mechanics, Worcester Polytechnic Institute	1893
KNOCH, JULIUS J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
KYSER, HENRY H. Clemson College, S. C.	Assistant Professor of Electrical Engineering, Clemson Agricultural College	1897
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LANE, HENRY M. Scranton, Pa.	Principal of the School of Mechanical Engineering, International Correspondence Schools	1900
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LANZA, GAETANO Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
LA RUE, BENJAMIN F. Scranton, Pa.	Principal School of Civil Engineering, International Correspondence Schools	1899

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Lawrence, James W...... Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College.........	1898
Love, Andrew C.......... College Station, Tex.	Assistant Professor of Drawing, Agricultural and Mechanical College of Texas	1900
Lund, Robert L.......... 2102 Hays St., Nashville, Tenn.	Adjunct Professor of Civil Engineering, Vanderbilt University.........	1902
McCaustland, Elmer J... Ithaca, N. Y.	Assistant Professor of Civil Engineering, Cornell University............	1902
McClintock, William E.. 15 Court Square, Boston, Mass.	Civil Engineer, Instructor in Highway Engineering, Harvard University, Cambridge, Mass.............	1898
McColl, Jay R........... La Fayette, Ind.	Associate Professor in Thermodynamics, Purdue University.........	1894
McNair, Fred W......... Houghton, Mich.	President, Michigan College of Mines.	1897
Mack, John G. D......... 222 Jefferson St., Madison, Wis.	Assistant Professor of Machine Design, College of Engineering, University of Wisconsin.................	1901
Macomber, Irwin J....... 422 Thirty-fourth St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology....	1902
Magowan, Charles S..... Iowa City, Iowa.	Assistant Professor of Civil Engineering, State University of Iowa......	1896
Magruder, William T.... Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University..............	1893
Mann, John L........... Hanover, N. H.	Associate Professor of Civil Engineering and Mechanical Drafting, Thayer School of Civil Engineering........	1902
Marburg, Edgar.......... Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania........	1894
Marston, Anson......... Ames, Iowa.	Professor of Civil Engineering, Iowa State College.................	1894
Marvin, Frank O......... Lawrence, Kan.	Dean of the School of Engineering, Professor of Civil Engineering, University of Kansas..............	1893

Name and Address.	Title.	Date of Membership.
Marx, Charles D. Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University	1893
Mather, Thomas W. New Haven, Conn.	Principal Boardman Manual Training High School	1894
Mathews, Hubert B. Brookings, S. Dak.	Professor of Physics, South Dakota Agricultural College	1896
Matthews, Charles P. Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University	1898
Maurer, Edward R. Madison, Wis.	Professor of Mechanics, University of Wisconsin.	1897
Mead, Elwood Washington, D. C.	Professor of the Institutions and Practice of Irrigation, University of California; Expert in charge of Irrigation Investigations of the U. S. Department of Agriculture	1901
Mees, Carl L. Terre Haute, Ind.	President, Rose Polytechnic Institute	1894
Mendenhall, Thomas C. Worcester, Mass.		1895
Merriman, Mansfield South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1893
Miggett, William L. 331 Jefferson St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan	1902
Miller, Robert S. Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University	1900
Moore, Stanley H. Kansas City, Mo.	Director Manual Training Department, Manual Training High School	1902
More, Charles C. 222 Rochelle Ave., Philadelphia, Pa.	Erecting Dep't American Bridge Co. of N. Y., Pencoyd, Pa	1901
Morley, Frederick Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan	1896
Munroe, Henry S. New York, N. Y.	Professor of Mining, Columbia University	1893

Name and Address.	Title.	Date of Membership.
Nagle, James C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
Neff, Frank H. Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science	1895
Nesbit, Arthur F. Durham, N. H.	Associate Professor of Physics and Electrical Engineering, New Hampshire College of Agriculture and Mechanic Arts	1902
Norris, Henry H. Ithaca, N. Y.	Assistant Professor of Electrical Engineering and Electrician to the Department of Light, Heat and Power, Cornell University	1900
Ordway, John M. New Orleans, La.	Professor of Biology, A. T. Newcomb College	1894
Orton, Edward, Jr. Columbus, Ohio.	Dean of College of Engineering, Director of the Department of Clay Working and Ceramics, State Geologist of Ohio, Ohio State University	1900
Ostrander, John E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
Owens, Robert B. Montreal, Que.	Professor of Electrical Engineering, McGill University	1894
Palmer, Walter K. 401 N. Y. Life Bldg., Kansas City, Mo.	Consulting Mechanical and Electrical Engineer	1899
Pence, William D. Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Pettee, Charles H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898
Phillips, James D. Madison, Wis.	Assistant Professor of Engineering Drawing, University of Wisconsin	1899
Porter, Dwight Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893

Name and Address.	Title.	Date of Membership
Price, Melvin Lincoln, Neb.	Instructor in Mechanical Drawing and Machine Design, University of Nebraska	1900
Pupin, Michael I. New York, N. Y.	Professor of Electro-mechanics, Columbia University	1895
Puryear, Charles College Station, Tex.	Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894
Raymond, William G. Troy, N. Y.	Professor of Geodesy and Road Engineering, Rensselaer Polytechnic Institute	1893
Reber, Louis E. State College, Pa.	Dean of School of Engineering, Professor of Mechanical Engineering, The Pennsylvania State College	1893
Richards, Charles R. Lincoln, Neb.	Professor of Mechanical Engineering and Director of the School of Mechanic Arts, University of Nebraska	1895
Richards, Robert H. Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
Richter, Arthur W. Madison, Wis.	Professor of Experimental Engineering, University of Wisconsin	1894
Ricker, N. Clifford Urbana, Ill.	Dean of College of Engineering, University of Illinois	1894
Ricketts, Palmer C. Troy, N. Y.	President and Director, Rensselaer Polytechnic Institute	1893
Riggs, Walter M. Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Mechanical Department, Agricultural and Mechanical College of South Carolina	1897
Robbins, Arthur G. Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
Robinson, Edward Potsdam, N. Y.	Professor of Mechanical Engineering, Clarkson School of Technology	1899

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP
ROBINSON, FREDERIC H. Newark, Del.	Professor of Civil Engineering, Delaware College	1894
ROBINSON, STILLMAN W. Columbus, Ohio.	Mechanical Engineer and Expert, 1353 Highland St	1893
ROSEBRUGH, THOMAS R. Toronto, Ontario.	Professor of Electrical Engineering, School of Practical Science	1896
RYAN, HARRIS J. 114 Cascadilla Place, Ithaca, N. Y.	Professor of Electrical Engineering, Sibley College, Cornell University	1901
SANBORN, FRANK E. Columbus, O.	Director Industrial Arts Department, Secretary of the College of Engineering, Ohio State University	1899
SCHMIDT, EDWARD C. Urbana, Ill.	Assistant Professor of Railway Engineering, University of Illinois	1899
SCHUERMAN, WILLIAM H. Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University	1895
SEDGWICK, WILLIAM T. Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology	1896
SHEPARDSON, GEORGE D. Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota	1895
SHORT, ROBERT L. 915 W. California Ave., Urbana, Ill.	Assistant Professor of Mathematics, University of Illinois	1902
SMITH, ALTON L. Worcester, Mass.	Assistant Professor of Drawing and Machine Design, Worcester Polytechnic Institute	1902
SMITH, HAROLD B. Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1898
SMITH, HARRY E. Brooklyn, N. Y.	Assistant Professor of Mechanical Engineering, Pratt Institute	1895
SMITH, HERBERT S. S. Princeton, N. J.	Professor of Applied Mechanics, Princeton University	1894
SNOW, CHARLES H. New York, N. Y.	Dean of School of Applied Science, New York University	1895

Name and Address.	Title.	Date of Membership.
Snow, Walter B. 29 Russel Ave., Watertown, Mass.	Mechanical Engineer, B. F. Sturtevant Co., Jamaica Plain, Mass.	1899
Solberg, Halvor C. Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College.	1894
Spalding, Frederick P. Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri	1893
Spangler, Henry W. Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania	1893
Sperr, Frederick W. Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines.	1896
Spinney, Louis B. Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College	1899
Springer, Frank W. Minneapolis, Minn.	Assistant Professor of Electrical Engineering, University of Minnesota	1896
Stanwood, James B. Cincinnati, Ohio.	Director, Technical School of Cincinnati	1894
Stewart, Clinton B. Anchor, Ill.	Civil Engineer	1894
Stewart, Lewis B. Toronto, Ontario.	Lecturer in Surveying, School of Practical Science	1897
Stout, Oscar Van P. Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska	1894
Stubbs, Joseph E. Reno, Nev.	President, Nevada State University	1897
Swain, George F. Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology	1893
Swift, Walter Sheffield, England.	Secretary of Technical Department, University College	1902
Talbot, Arthur N. Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois.	1893
Talbot, Henry P. Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1902

Name and Address.	Title.	Date of Membership.
Taylor, Thomas U......... Austin, Texas.	Professor of Civil Engineering, University of Texas..................	1902
Taylor, William D........ 415 Wisconsin Ave., Madison, Wis.	Professor of Railway Engineering, University of Wisconsin............	1894
Thaler, Joseph A......... Minneapolis, Minn.	Instructor in Drawing and Mechanical Laboratory, University of Minnesota	1901
Thomas, Robert G......... Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy...	1894
Thompson, William O..... Columbus, O.	President, Ohio State University.............	1899
Thornburg, Charles L..... South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University............	1894
Thurston, Robert H....... Ithaca, N. Y.	Director of Sibley College, Cornell University................	1893
Timmerman, Arthur H..... St. Louis, Mo.	Superintendent Wagner Electric Mfg. Co.	1894
Towle, William M......... Syracuse, N. Y.	Associate Professor of Practical Mechanics, Smith College, Syracuse University	1895
Turneaure, Frederick E... Madison, Wis.	Professor of Bridge and Sanitary Engineering, University of Wisconsin..	1894
Turner, Daniel L......... Cambridge, Mass.	Instructor in Surveying and Hydraulics, Lawrence Scientific School, Harvard University...............	1898
Turner, William P........ Lafayette, Ind.	Assistant Professor of Practical Mechanics, Purdue University.........	1900
Tyler, Harry W........... 419 Boylston St., Boston, Mass.	Professor of Mathematics, and Secretary, Massachusetts Institute of Technology	1894
Van Ornum, J. L.......... St. Louis, Mo.	Professor of Civil Engineering, Washington University............	1895
Vedder, Herman K........ Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College.	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
VOTEY, J. WILLIAM Burlington, Vt.	Professor of Civil Engineering, University of Vermont	1902
VOSSKUEHLER, JOSEPH H. Columbus, Ohio.	Instructor in Drawing, Ohio State University	1902
WADDELL, J. A. L. Kansas City, Mo.	Consulting Bridge Engineer, of Waddell and Hedrick	1893
WADSWORTH, JOEL E. 22 Marsemere Place, Yonkers, N. Y.	Assistant Chief Engineer, Operating and Engineering Department, Eastern Division, American Bridge Co.	1895
WADSWORTH, M. EDWARD State College, Pa.	Professor of Mining and Geology, Pennsylvania State College	1895
WALDO, CLARENCE A. Lafayette, Ind.	Professor of Mathematics, Purdue University	1897
WALKER, ELTON D. State College, Pa.	Professor of Hydraulic and Sanitary Engineering, The Pennsylvania State College	1895
WEBB, HOWARD S. Orono, Me.	Professor of Electrical Engineering, University of Maine	1897
WELLS, JAMES H. 624 N. Sixth Street, Lafayette, Ind.	Mechanical Engineer	1897
WHIPPLE, GEORGE C. Brooklyn, N. Y.	Director of Mt. Prospect Laboratory, Flatbush Ave. and Eastern Parkway.	1896
WHITE, JAMES McLAREN Champaign, Ill.	Professor of Architectural Engineering, University of Illinois	1900
WHITNEY, WILLIAM R. Boston, Mass.	Assistant Professor of Theoretical Chemistry and Proximate Technical Analysis, Massachusetts Institute of Technology, Boston, Mass., Director of Research Laboratory of the General Electric Company, Schnectady, N. Y.	1902
WILLETT, JAMES R. 434 Jackson Boulevard, Chicago, Ill.	Architect	1896
WILLIAMS, FRANK B. 12 Gillespie Street, Schenectady, N. Y.	Associate Professor of Engineering, Union College	1901

Name and Address.	Title.	Date of Membership.
Williams, Sylvester N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
Williston, Arthur L. Brooklyn, N. Y.	Director Department of Science and Technology, Pratt Institute	1897
Wilmore, John J. Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
Wilson, Victor T. Ithaca, N. Y.	Instructor in Freehand and Mechanical Drawing, Cornell University	1898
Wing, Charles B. Stanford University, California.	Professor of Structural Engineering, Leland Stanford Junior University	1895
Wood, Arthur J. Newark, Del.	Professor of Mechanical and Electrical Engineering, Delaware College.	1898
Woodward, Calvin M. St. Louis, Mo.	Dean of the School of Engineering and Architecture, Washington University	1894
Woodward, Robert S. New York, N. Y.	Professor of Mechanics and Mathematical Physics, Columbia University	1893
Wright, Charles H. C. Toronto, Ont.	Lecturer in Architecture, School of Practical Science	1897
Zimmerman, Oliver B. 222 Charter St., Madison, Wis.	Assistant Professor of Machine Design, University of Wisconsin	1902
Ziwet, Alexander Ann Arbor, Mich.	Professor of Mathematics, University of Michigan	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Alabama.—Crenshaw, Fullan, Wilmore.

Arkansas.—Knoch.

California.—Christy, Cruikshank, Hoskins, Kidwell, Marx, Wing.

Colorado.—L. G. Carpenter, Chauvenet, Lawrence.

Connecticut.—Barney, DuBois, Mather.

Delaware.—Brown, F. H. Robinson, Wood.

District of Columbia.—Mead.

Illinois.—Alderson, Arnold, Baker, Breckenridge, Brill, M. Brooks, Frink, Goodenough, Kerr, Macomber, Ricker, Schmidt, Short, C. B. Stewart, A. N. Talbot, White, Willett.

Indiana.—Burrage, Goldsborough, Goss, Gray, Hatt, M. A. Howe, McColl, Matthews, Mees, Miller, Pence, W. P. Turner, Waldo, Wells.

Iowa.—S. W. Beyer, Bissell, Lanphear, Magowan, Marston, Spinney, S. N. Williams.

Kansas.—Diemer, Marvin.

Kentucky.—F. P. Anderson, J. P. Brooks, Faig.

Louisiana.—D. S. Anderson, Ayers, Creighton, Ordway.

Maine.—Grover, Hamlin, Webb.

Maryland.—Flint, A. W. Harris.

Massachusetts.—Adams, Allen, Anthony, Bray, Chandler, Chase, Dean, Engler, A. W. French, Hofman, Hollis, Ives, Johnson, F. R. Jones, Kinealy, Kingsbury, Lanza, McClintock, Mendenhall, Ostrander, Peabody, D. Porter, R. H. Richards, Robbins, Sedgwick, A. L. Smith, H. B. Smith, W. B. Snow, Swain, H. P. Talbot, D. L. Turner, Tyler, Whitney.

Michigan.—Bixby, Cooley, Denison, F. W. Denton, Fisher, Hood, McNair, Miggett, Morley, Sperr, Vedder, Ziwet.

Minnesota.—Brooke, Constant, Eddy, Flather, Frankforter, Groat, Haynes, Hoag, Kavanaugh, Shepardson, Springer.

Mississippi.—Hume.

Missouri.—Fernald, Harper, Ladd, Moore, Palmer, Spalding, Zimmerman, Van Ornum, Waddell, C. M. Woodward.

Montana.—Gill, Thaler.

Nebraska.—Chatburn, Davis, Price, C. R. Richards, Stout.

Nevada.—Stubbs.

New Hampshire.—Colby, Fletcher, Hawes, Hazen, Holden, Mann, Nesbit, Pettee.

New Jersey.—J. E. Denton, Jacobus, Kent, H. S. S. Smith.

New York.—Aldrich, Barr, Berg, Browne, Burr, R. C. Carpenter, Colburn, Corthell, Crandall, Duncan, Durand, Farwell, Fuertes, Griffin, Haviland, Hibbard, Hutton, Jacoby, Kay, Landreth, McCaustland, Munroe, Norris, Pupin, Raymond, Ricketts, E. Robinson, Ryan, H. E. Smith, C. H. Snow, Thurston, Towle, J. E. Wadsworth, Whipple, F. B. Williams, Williston, Wilson, R. S. Woodward.

Ohio.—Benjamin, Bradford, Caldwell, T. E. French, Hitchcock, C. S. Howe, Magruder, Neff, Orton, S. W. Robinson, Sanborn, Staley, Stanwood, Thompson, Vosskuehler.

Pennsylvania.—Ayer, T. R. Beyer, Brady, Bruegel, Carhart, Drown, Dudley, Esty, Foss, Franklin, E. G. Harris, J. P. Jackson, Lambert, Lane, LaRue, Marburg, Merriman, More, J. M. Porter, Reber, Spangler, Thornburg, M. E. Wadsworth, Walker.

Rhode Island.—Blanchard, Hill.

South Carolina.—Kyser, Riggs, Thomas.

South Dakota.—Mathews, Solberg.

Tennessee.—Carson, Lund, Schuerman.

Texas.—Giesecke, Halsted, Love, Nagle, Puryear, T. U. Taylor.

Vermont.—Barrows, Freedman, Votey.

Virginia.—Humphreys, Jett, Randolph.

Washington.—Fuller.

West Virginia.—Emory, C. R. Jones.

Wisconsin.—Bull, Burgess, D. C. Jackson, Mack, Maurer, Phillips, Richter, W. D. Taylor, Turneaure, Zimmerman.

Australia.—Barraclough.

Canada.—Bovey, Brydone-Jack, Galbraith, Owens, Rosebrugh, L. B. Stewart, Wright.

England.—Swift.

DIFFERENT INSTITUTIONS REPRESENTED:—

Colleges and Universities teaching engineering	73
Manual Training Schools	8
Correspondence Schools (3 representatives)	1

One institution is represented by 13 members; two by 11; one by 10; two by 9; two by 8; one by 6; four by 5; ten by 4; twelve by 3; seventeen by 2; twenty-four by 1. Manual Training Schools by 8.

Teachers, and, in many cases, also practicians	247
Practicians not teachers	31
Total	278

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	3	Massachusetts	31	South Dakota	2
Arkansas	1	Michigan	13	Tennessee	3
California	6	Minnesota	11	Texas	6
Colorado	3	Mississippi	1	Vermont	3
Connecticut	3	Missouri	10	Virginia	3
Delaware	3	Montana	1	Washington	1
District of Columbia.	1	Nebraska	5	West Virginia	2
Illinois	16	Nevada	1	Wisconsin	9
Indiana	14	New Hampshire	8	Australia	1
Iowa	7	New Jersey	4	Canada	7
Kansas	2	New York	38	England	1
Kentucky	3	Ohio	14		
Louisiana	4	Pennsylvania	24	Total	275
Maine	3	Rhode Island	2		
Maryland	2	South Carolina	3		

37 States, District of Columbia, Canada, and 2 Foreign Countries.

DECEASED MEMBERS.

NAME.	YEAR OF ELECTION.	DATE OF DEATH.	MEMOIR. Vol. Page.
VOLNEY G. BARBOUR	1894	June 4, 1901.	IX, 340
CHARLES B. BRUSH	1893	June 3, 1897.	VII, 181
ECKLEY B. COXE	1894	May 13, 1895.	VII, 182
FRANCIS R. FAVA, JR.	1894	March 28, 1896.	VII, 183
HENRY FULTON	1894	December 6, 1901.	X, 258
HERBERT G. GEER	1894	March 7, 1900.	VIII, 371
JOHN B. JOHNSON	1893	June 23, 1902.	X, 259
RODNEY G. KIMBALL	1894	April 25, 1900.	X, 261
JUSTUS M. SILLIMAN	1894	April 15, 1896.	VII, 184
JAMES H. STANWOOD	1894	May 24, 1896.	VII, 185
ALPHONSE N. VAN DAELL.	1897	March 28, 1899.	VII, 186
JOHN R. WAGNER	1894	January 21, 1899.	VII, 187
FRANCIS A. WALKER	1896	January 5, 1897.	VII, 188
NELSON O. WHITNEY	1893	March 17, 1901.	IX, 339
DE VOLSON WOOD	1893	June 27, 1897.	V, 325

PAST OFFICERS.

Special Committee for Division E (Engineering Education), World's Engineering Congress, 1893.

IRA O. BAKER, Chairman,
HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary,
C. FRANK ALLEN, Secretary, *pro tem.*,
MORTIMER E. COOLEY,
SAMUEL W. STRATTON,
STORM BULL.

PRESIDENTS

DE VOLSON WOOD,[*] 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON,[†] 1897–8.
THOS. C. MENDENHALL, 1898–9,
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN, 1900–01,
ROBERT FLETCHER, 1901–02,

VICE-PRESIDENTS.

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON, FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY, ALBERT KINGSBURY, 1900–01,
STORM BULL, CALVIN M. WOODWARD, 1901–02.

TREASURERS.

STORM BULL, 1893–5,
JOHN J. FLATHER, 1895–9,
CLARENCE A. WALDO, 1899–1902.

SECRETARIES.

JOHN B. JOHNSON, 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900,
HENRY S. JACOBY, 1900–02.

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[*] Died June 27, 1897. [†] Died June 23, 1902.

MEMBERS OF PREVIOUS COUNCILS.

Terms of Office Expired in 1894.

M. E. Cooley,
H. T. Eddy,
W. F. M. Goss,
W. R. Hoag,
S. W. Robinson,
H. W. Spangler,
R. H. Thurston.

Terms of Office Expired in 1895.

H. T. Bovey,
W. H. Burr,
O. H. Landreth,
Mansfield Merriman,
W. G. Raymond,
G. F. Swain,
De Volson Wood.*

Terms of Office Expired in 1896.

I. O. Baker,
Storm Bull,
S. B. Christy,
John Galbraith,
J. B. Johnson,†
F. O. Marvin,
C. D. Marx.

Terms of Office Expired in 1897.

H. T. Eddy,
J. J. Flather,
J. P. Jackson,
Albert Kingsbury,
L. S. Randolph,
S. W. Robinson,
R. H. Thurston.

Terms of Office Expired in 1898.

C. F. Allen,
C. L. Mees,
Mansfield Merriman,
J. M. Ordway,
W. G. Raymond,
Cadey Staley,
R. S. Woodward.

Terms of Office Expired in 1899.

Arthur Beardsley,
Robert Fletcher,
John Galbraith,
William Kent,
T. C. Mendenhall,
W. H. Schuerman,
M. E. Wadsworth.

Terms of Office Expired in 1900.

Storm Bull,
L. G. Carpenter,
Albert Kingsbury,
F. O. Marvin,
R. B. Owens,
R. L. Sackett,
R. H. Thurston.

Terms of Office Expired in 1901.

T. M. Drown,
M. A. Howe,
I. N. Hollis,
Gaetano Lanza,
P. C. Ricketts,
R. G. Thomas,
C. M. Woodward.

Terms of Office Expired in 1902.

Brown Ayers,
G. W. Bissell,
J. J. Flather,
W. T. Magruder,
F. W. McNair,
J. M. Porter,
A. J. Wood.

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* Died June 27, 1897.

† Died June 23, 1902.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. They shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting.

3. OFFICERS.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the past Presidents of the Society shall be members of the Council *ex officiis.*

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. NOMINATING COMMITTEE.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any

meeting be less than five, the President shall make appointments so as to form a committee of five.

6. **Fees and Dues.**—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearage shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. **Meetings.**—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

8. **Publication.**—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. **Amendments.**—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a programme for the same.

Second. The President, Secretary and Treasurer shall constitute an executive committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PROCEEDINGS.

FRIDAY, JUNE 27, 1902.

MORNING SESSION, 10:30 O'CLOCK.

The tenth annual meeting of the Society was held in Pittsburg, Pa., June 27 and 28, 1902.

The meeting was called to order by the President, Robert Fletcher.

The President announced the sad news which had just been received of the sudden death of Past President John Butler Johnson and on motion a committee consisting of Past Presidents Merriman, Eddy and Marvin, and of Professors C. M. Woodward, Raymond and Allen was appointed to prepare suitable resolutions.

The report of the Secretary was read and adopted.

The report of the Treasurer was read, and the President announced that the Council had referred the report to an Auditing Committee consisting of Professors Talbot and McNair.

The following thirty-two applicants, approved by the Council were elected members of the Society: Stanley H. Moore, John Henry Barr, Clarence Austin Chandler, Fred. Goodrich Frink, Arthur Fleming Nesbit, Irwin John Macomber, Ellery William Davis, Robert Louis Short, Oliver Brunner Zimmerman, J. William Votey, Carter Coleman Jett, William Harrison Kavanaugh, William Rodney Whitney, William Ellsworth Brooke, Henry Paul Talbot, Thomas

Uloan Taylor, William Horatio Freedman, Harold Warner Brown, Charles Volney Kerr, Walter Swift, Robert Leathan Lund, Alton Lincoln Smith, Joseph Henry Vosskuehler, Harold Kilbreth Barrows, Arthur Horace Blanchard, Edwin Haviland, Jr., Elmer James McCaustland, Charles Sumner Howe, Irving Atwell Colby, William Lincoln Miggett, Hugo Diemer, John Laroy Mann.

The literary exercises of the meeting were opened with the delivery of the Annual Address by the President, Robert Fletcher, on "The Efficiency Factor in Engineering Education."

This was followed by a discussion of "The Value of Non-resident Lectures on Engineering Subjects." A written discussion prepared by Professor George F. Swain was read by Professor C. Frank Allen, and one prepared by Professor Robert H. Thurston was read by the Secretary. Another written discussion was received from Professor William D. Pence. The subject was discussed orally by Professors C. M. Woodward, Allen, Eddy, and Kingsbury.

AFTERNOON SESSION, 2:30 O'CLOCK.

The Committee appointed to draft resolutions on the death of Past President Johnson made the following report:

"The members of the Society for the Promotion of Engineering Education desire to place upon record their high appreciation of the life and character of their late associate, John Butler Johnson, whose sudden and untimely death has filled all hearts with profound grief. In his eminence as an engineer, his brilliant success as an instructor and inspirer of youth, in his capacity as an organizer of engineering education, and in his character as a man, his record is one of which this Society may well be proud.

"He was one of the active founders of this body, its first secretary, and later its president. His influence, enthusiasm and indefatigable labors in its behalf have contributed much to whatever success it has achieved. The Society mourns the loss of one whose place it will be impossible to fill. The engineering profession has lost one of its ablest thinkers, writers and teachers.

"To his bereaved wife and children the Society extends the tenderest sympathy, and the tribute of a common sorrow.

"*Resolved,* that this expression of affection and respect be published in our Proceedings, and that a copy duly signed by the President and Secretary be transmitted to Mrs. Johnson."

[Signed] MANSFIELD MERRIMAN,
HENRY T. EDDY,
F. O. MARVIN,
C. M. WOODWARD,
C. FRANK ALLEN,
WM. G. RAYMOND,
Committee.

On motion the resolutions were unanimously adopted by a rising vote, and the Secretary was instructed to forward a copy also to the institution in which Professor Johnson was serving at the time of his death.

A paper on "Methods of Grading Students in Engineering Colleges" by Professor Charles P.

Matthews was read by the author and discussed by Professors Caldwell, C. M. Woodward, A. W. French, Kingsbury, Allen, Flather, C. S. Howe and Raymond.

Professor Francis C. Caldwell then read his paper on "Laboratory Notes and Reports," which was afterwards discussed by Professors H. E. Smith, Emory, and Spangler.

The next paper, on "Electrochemistry as an Engineering Course," was read by the author, Professor Charles F. Burgess, and on motion its discussion was postponed until after the reading of Professor Orton's paper on "The Subdivision of the Field of Chemical Engineering Education."

The following members took part in an adjourned discussion of the first three topics of Professor William G. Raymond's paper presented in 1901. See Proceedings, Volume IX., pages 142–148: Professors Talbot, Mees, Merriman, C. M. Woodward, C. S. Howe, Johnson, McNair, Williston, Caldwell, Tyler, Flather, Wood, J. P. Jackson, A. W. French, Waldo, and Raymond. The opening discussions by Professors Talbot and Mees were written, while the rest were oral.

SATURDAY, JUNE 28, 1902.

MORNING SESSION, 10 O'CLOCK.

The Secretary reported that the Council had approved the applications for membership of Daniel Carhart, and Ernest Edmund Brydone-Jack, and they were accordingly elected.

Professor Mansfield Merriman presented the report of the Nominating Committee, which, according to the Constitution, consisted of Past Presidents Merriman, Eddy, and Marvin, and of Councilors Allen, Nagle, and Williston. The nominees were unanimously elected, as follows:

President, Calvin M. Woodward.

Vice-Presidents, John J. Flather and Frederick W. McNair.

Secretary, Clarence A. Waldo.

Treasurer, Arthur N. Talbot.

Members of the Council, terms to expire in 1905, William Esty, Henry S. Jacoby, Lewis J. Johnson, Elwood Mead, Edward Orton, Jr., William M. Towle.

Professor Gray read the following report which had previously been presented to the Council:

"To the Council of the Society for the Promotion of Engineering Education: Your Committee on the question of the advisability of appointing a committee on requirements for graduation beg to report as follows:

(*a*) *Against.*

"Such a committee is not necessary or desirable because the character of the work done in this country necessarily depends largely on that of the preparatory schools from which the colleges draw their students. Institutions in the West, for example, do not, as a rule, receive students as well prepared as those in the East and hence it would be difficult to bring all to the same standard for graduation. The strength of the educational institutions of this country largely depends on their individuality. While it is to be regretted that there are weak schools and that degrees may occasionally be given unworthily, yet the present system seems to be stimulating to vigorous life and should not be greatly interfered with. Any attempt to mold the work of all institutions to a given form is believed to be contrary to the spirit of American institutions and likely to do harm rather than good.

(*b*) *For.*

"This seems a legitimate subject for careful consideration and published opinion by this Society. There is at present a wide variation in the courses of study leading to degrees in engineering. In some cases the degree certifies to little more than the completion of a high school course and in others practically only to a knowledge of applied mathematics.

"Other learned professions are rapidly adopting specific qualifications for degrees and it is important that engineers should do the same if engineering is to take rank as a learned profession.

"The courses of study are at present too much dependent on the peculiarities of individual men without reference to recognized authority, and hence some statement by this Society of the opinion of its members as a body is desirable as a guide. It is very desirable that some authoritative statement should be made as to what a member of the several branches of engineering should know at the various stages of his advancement. This subject involves not only the meaning of the purely collegiate degree but also of the subsequent degrees. There is at present considerable difference of opinion as to what the duties of the colleges are in regard to granting diplomas, which may be in many ways misleading. Many colleges adhere to this idea that the degree given at the end of the course should be only a stamp of scientific knowledge and that any degree containing the title engineer should not be given until the candidate has shown ability in the practice of his profession.

"It is the opinion of the majority of the members of this committee that there is good reason for the appointment of a committee of the Society to consider and report on this subject, the object not being any classification of colleges, nor any advertisement of data as to what any one college does or does not, but the formulation of a statement of opinion as to what is the most desirable course to pursue and what minimum of attainment should be considered sufficient for the first, second, etc., degrees."

The advisability of appointing a Committee on Requirements for Graduation was in 1901 referred to the Council with power, and the Council then appointed a committee consisting of the seven councilors whose terms expire in 1904 to report to the Council in 1902 an argument against and an argument in favor of the appointment of such a committee. This was done and the Council voted to recommend to the Society the appointment of a Committee on Requirements for Graduation.

On motion the discussion and final action upon the report was deferred until the afternoon session.

Professor Elwood Mead presented his paper on "Courses of Instruction in Irrigation Engineering." As the entire paper was printed in advance the author commented upon the principal items, and this was followed by a discussion in which Professors Nagle, Emory, C. M. Woodward, and Mead took part.

The paper on "The Subdivision of the Field of Chemical Engineering," by Edward Orton, Jr., was read by the author and was discussed, in connection with Professor Burgess' paper on "Electrochemistry as an Engineering Course," by the following members: Professors Browne, Williston, J. P. Jackson, Emory, Orton, Merriman, Frankforter, Caldwell and Burgess. The discussion by Professor Browne was communicated by letter and read by the Secretary.

Professor Arthur W. French presented a written discussion on "Some Abuses of the Lecture System" and the oral discussion was continued by Professors Spangler, C. M. Woodward, Emory, Allen, A. W. French, and Kingsbury.

A report of the Committee on Statistics of Engineering Education was read by the chairman, Professor William T. Magruder, and after a discussion by Professor Spangler, it was directed that the report be printed in the Proceedings and that the Committee be continued. On motion the recommendation of the Committee was adopted, requesting the coöperation of engineering colleges in securing the proposed statistics.

AFTERNOON SESSION, 2 O'CLOCK.

Professor Calvin M. Woodward read his paper on "The Management of Intercollegiate Athletics." In the discussion which followed the speakers were Professors J. C. Jackson, Waldo, Jacoby, R. S. Woodward, Spangler, and C. M. Woodward.

The paper on "Over-development in Engineering Laboratory Courses" was read by the author, Professor Frederick P. Spalding.

The report of the Committee on Entrance Requirements for Engineering Colleges was read by the Chairman, Professor Harry W. Tyler, and discussed by Professor C. M. Woodward. On motion the report was adopted and ordered to be printed in the Proceedings.

The further discussion on "Excessive Differentiation in Engineering Courses" (see Professor Nagle's paper and its discussion, 1901, in Proceedings, Volume IX., pages 112–141) was opened with a written discussion by Professor Edgar Marburg which, in the absence of the author, was read by Professor Henry W. Spangler. Professor William T. Magruder and C. Frank Allen also presented written discussions, while Professors C. M. Woodward, Emory, Nagle, Allen, Brydone-Jack, Waldo, Talbot, Nagle, L. J. Johnson, and Marvin participated in the oral discussion.

Professor Henry T. Eddy, in behalf of a committee appointed by the Council to consider the vacancies in the membership and chairmanship of the Committee on Industrial Education due to the death of Professor J. B. Johnson, recommended that Professor Arthur L. Williston be elected to fill the vacant membership, and that Professor Calvin M. Woodward be elected chairman of the committee. On motion, the report was adopted.

On motion, the recommendation of the Council that a Committee on Requirements for Graduation be appointed was adopted, and the President elect was authorized to appoint the committee at his early convenience.

The meeting then adjourned.

The following members registered and were present at the meeting: C. F. Allen, F. W. Brady, H. W. Brown, C. F. Burgess, F. C. Caldwell, J. A. Colby, F. H. Constant, C. L. Crandall, H. Diemer, H. T. Eddy, F. L. Emory, J. J. Flather, R. Fletcher, A. W. French, T. Gray, B. F. Groat, G. B. Halsted, J. H. Hawes, O. P. Hood, C. S. Howe, J. P. Jackson, H. S. Jacoby, L. J. Johnson, C. R. Jones, E. B. Kay, A. Kingsbury, F. W. McNair, W. T. Magruder, J. L. Mann, F. O. Marvin, C. P. Matthews, E. Mead, C. L. Mees, M. Merriman, W. L. Miggett, J. C. Nagle, F. H. Neff, E. Orton, Jr., C. Puryear, W. G. Raymond, L. E. Reber, W. M. Riggs, F. E. Sanborn, H. E. Smith, F. P. Spalding, H. W. Spangler, A. N. Talbot, W. M. Towle, F. E. Turneaure, H. W. Tyler, H. K. Vedder, C. A. Waldo, A. L. Williston, J. J. Wilmore, A. J. Wood, C. M. Woodward, R. S. Woodward.

HENRY S. JACOBY, *Secretary.*

REPORT OF THE SECRETARY.

The membership of the Society at the opening of the last annual meeting was reported as 261. As a notice of the death of one of the members failed to reach the Secretary before the meeting the number of members was really 260 at that time. At the meeting fifteen applicants for membership were elected. During the past year eight members resigned, most of whom have retired from the ranks of engineering teachers, while twelve members have been dropped in accordance with the constitution for the non-payment of dues.

The Society lost one of its members by death on December 6, 1901: Henry Fulton, Professor of Civil Engineering of the University of Colorado. He was a member of the Society since 1894. A memoir has been prepared for publication in the next volume of the Proceedings.

Since coming to the place of meeting the news has been received of the sudden death on June 23 of John Butler Johnson, Dean of the College of Engineering, University of Wisconsin. He was a member of the Society since its organization, its first secretary and a past president.

The changes referred to above leave a membership of 253 at the beginning of this meeting.

HENRY S. JACOBY, *Secretary.*

REPORT OF TREASURER.

The Treasurer of the Society would respectfully report as follows:

The total receipts during the year 1901–02 to date of the annual meeting have been $882.30, as against $953.88 last year. Of this amount $697.50 was for current dues, last year, $683.50; $72 past fees and dues, last year, $132; $69.30 from sale of Proceedings, last year $95.29. The balance on hand this year is $316.87, as against $287.05 at the end of last year.

Thirteen members elect, all qualified. During the year the membership has become more compact and reliable. The membership is getting in the habit of keeping dues up to date.

The surplus has been protected, which is an important feature in the economical administration of the Society's affairs.

Respectfully submitted,

C. A. WALDO, *Treasurer.*

The following is the report in detail.

C. A. Waldo, Treasurer, in account with the Society for the Promotion of Engineering Education. Dr. to the following

RECEIPTS.

Cash on hand, June 29, 1901	$ 287	05
Sale of Proceedings	69	30
Sale of Technical Educational Reports	1	50
Sale to authors of extras	42	00
Past dues	72	00
Current and future dues	697	50
Total	$1,169	35

Cr. by the following

DISBURSEMENTS.

Former Secretary's expense	$ 5	30
Buffalo expense, 1901	21	00
Stenographer, Buffalo meeting	125	00
Proceedings, Vol. IX., printing, binding and wrapping	386	33
Postage, telegraph, express and freight on same	46	02
Reprints of papers, printing and expressage	40	15
Secretary's supplies and expense	97	50
Committee on Entrance Requirements	24	43
Secretary's honorarium	50	00
Treasurer's supplies and expenses	31	15
Badges	5	10
Chicago Committee	20	50
Balance, cash on hand	316	87
Total	$1,169	35

The Auditing Committee reported as follows:

"We have compared the items in the previous record with corresponding vouchers and have added the items and find the record correct in every particular."

[Signed] A. N. TALBOT,
F. W. MCNAIR,
Auditing Committee.

ADDRESS BY THE PRESIDENT.

BY ROBERT FLETCHER,

Director of Thayer School of Civil Engineering, Dartmouth College.

THE EFFICIENCY FACTOR IN ENGINEERING EDUCATION.

Members of the Society for the Promotion of Engineering Education:

The title of our Society expresses the object of this convention. The large proportions and wide relations of this interest come into clearer view with the advancing years. We come from widely separated localities, from different environments and from institutions variously organized and conducted, to take counsel together. Our high ideals may need readjustment. We are confronted by limitations both personal and material. Our work and duty as teachers must not fail to conform to the rapidly changing conditions and demands of the active interests which we strive to serve.

The second article of our constitution reads:

"Members of the Society shall be those who occupy or have occupied responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council."

Our last printed roll of membership shows a total of 261. Among these the practising engineers, not teachers, constitute about 10 per cent., classified as 11 civil, 7 mechanical, 2 each of mining and electrical, and 5 otherwise. Those who are both teachers and practitioners hold a proportion of 18 to 20 per cent. or more, divided between civil, mechanical, mining, electrical and scattering, as the numbers, 28, 9, 3, 5 and 2. Those who are teachers only or chiefly in the departments named aggregate about 45 to 47 per cent., divided respectively as the numbers, 47, 40, 5, 22 and 7. About 3 per cent. are identified chiefly with instruction in pure technics, such as manual training, etc. About 21 per cent. give the indispensable and fundamental preparation in mathematics, mechanics and the physical sciences. It will be noted that 33 per cent. of the total are committed to civil engineering, 22½ per cent. to mechanical, about 11 per cent. to electrical and about 9½ per cent. to mining and other branches. The balance of 24 per cent. constitutes the teachers in preparatory courses and the practicians.

The nine fruitful years of our Society's existence have given as many volumes of Proceedings, containing about 179 papers and reports of committees. These may be broadly separated into two grand divisions, viz:

A. Those treating of general topics, affecting our policy in the large.

B. Those relating to details and special methods, qualifications, etc.

Under the first head the writer has placed 82, or 46 per cent. These may be divided into five sections: (1) Engineering education in the ideal—general policy, education versus culture, electives, etc.—about 31. (2) Instruction in general, management, research, theses, etc.—20. (3) Equipment as to general features—5. (4) Graduation and degrees—8. (5) Historical, comparative, tendencies, etc.—18. The second grand division, including about 54 per cent., may be arranged in three sections: (1) Papers and reports relating to teaching in special departments, methods and details—59, or one third of the total in both divisions. (2) Those relating to apparatus and equipment for specific purposes—14. (3) Those relating to preparatory studies, conditions of admission and auxiliary branches—24. Independently of this classification we notice eight papers which deal with questions of manual training and technology in its restricted sense—as relating to industrial art; of these we find five assignable to division *A* and three to division *B*.

These papers, reports and discussions embody the matured convictions, ripe experience and "happy thoughts" of those most competent to speak on such themes. Evidently, if our Society is fulfilling its aim, they must have some permanent value and influence. The volumes should be kept, not on some top shelf, like the back numbers of a magazine, but close at hand for reference and for counsel.

Our standing committees have in hand important investigations, to which they are giving much time and labor. That on Requirements for Admission has a complicated and perplexing task. It has, doubtless, exerted far-reaching influence towards the raising of standards. Considering the variety of requirements, conditions and aims of our widely separated institutions, it is not to be expected that there will be ultimately very close agreement in opinion or entire unanimity of action. Lately we have given considerable attention to the question of requirements for graduation. There can be no doubt that this has a yet larger importance to us, because it determines more directly the quality of the product—the outcome upon which the practical world beyond will pass judgment. Here, if only approximate uniformity could be secured, there would be great gain both to our institutions and to the profession at large.

The Committee on Statistics has to do with a mass of multiplying details and figures which are of importance to us as furnishing the data upon which alone we can form intelligent conclusions as to the end just stated, and others. Obviously the inquiries should be made with discrimination, so as to include only such facts as are essential. It may not be amiss to remind our members that we owe it to all of the committees to give prompt and full response when they call upon us for information. A manifest general interest will lighten their labors.

The Committee on Technical Books for Libraries is doing an important work which will equally demand generous coöperation.

The Committee on Industrial Education is studying for us a great movement, the importance of which was first brought fairly into the forum of our Society at the Boston meeting, four years ago. The Committee has no report to make now, since the U. S. Commissioner of Labor is making investigations and collecting statistics. But this is a question of another phase of technical education, which has broadened out in recent years and now obtrudes itself increasingly upon our attention. In adjusting ourselves to this line of advance we have to consider definitions, and may digress a moment to scrutinize our terms.

Engineering education, technical education, industrial education or training, technical training—these are not terms that involve "distinction without a difference." The distinction made by the dictionary between engineering and technology is plain enough, to wit: *Engineering* includes the science and art of construction in general; to which we may add the knowledge of processes and appliances by which materials of construction are produced. That this intent is expressed in our organization appears from the personnel of the membership and the trend of the papers and discussions. On the other hand, *technology* is defined as inclusive of "industrial science; the science of systematic knowledge of the industrial arts, especially of the more important manufactures." The range and variety of arts and operations under technology is known only to few, and can hardly be comprehended by any one person. Many are based upon the highest scientific research and exhibit applications of the most exact technical knowledge and skill. Hence a broad and appropriate distinction may be recognized in the statement that both engineering education and technical training have assumed national and international importance. They are now chief factors in determining commercial success and supremacy. Tredgold's definition of the engineer, as one who directs the sources of power in nature to the use and convenience of man, is certainly broad and inclusive, but the range of technology in his day was quite limited. Whether he would have included both engineering and technology to-day, we cannot know.

In presenting a few thoughts on

The Efficiency Factor in Engineering Education we face at once the ancient question of *education* versus *training*. Although technical education has been under lively discussion among American engineers and educators for nearly thirty years, it is only yesterday, as it were, that the president of a leading institute of technology thought it necessary to utter an emphatic warning against the danger of putting too much stress upon mere *training*, to the neglect of the broader education. And, although as far back as the Philadelphia discussion of 1876, methods in England were criticised because the results came so far short of the American ideal of engineering education, being too much limited to training of artisans—yet only within five years the leading engineering journal of Great Britain has poured contempt upon the inadequate and misdirected system still in vogue there—showing the vast difference between educating well-fitted men to become directors of works and masters of professions, and the endeavor to teach workmen and trades-hands much that they cannot properly utilize. Quoting President Lincoln's adage that you can fool all the people some of the time and some of the people all the time, but not all of the people all of the time, the editor remarked: "In the matter of technical education we are hardly yet advanced here beyond Mr. Lincoln's first stage. The 'fooling' which provided the enormous sums wasted in London polytechnics has been pretty universal, but recently one or two voices have been calling out of the wilderness of delusion, and will doubtless enlighten the public as to the general bearings of the question.

Progress is, however, slow and the gentlemen who at the recent London Technological Congress defended the absurd panegyric of the late County Council chairman, on the immense advantages of a knowledge of chemistry to a bricklayer, must no doubt be reckoned among Mr. Lincoln's 'all the timers.'"

There is variety and inconsistency in the titles of our institutions. Polytechnic Institute designates the oldest American engineering college and several younger colleges, whether devoted to civil engineering chiefly or to mechanical engineering, or to both; or in recent years including also electrical engineering. A similar term—technical institute—marks many younger training schools where manual training, and more strictly industrial education, are emphasized. Among these are institutes noted for munificent endowment and extensive equipment, and for the important work they are successfully doing. Our easternmost institute of technology has long covered nearly the entire field of engineering practice by high-grade instruction and technical training. Our oldest "school of mines" teaches engineering beyond mining; some later schools of mines aim only to make good that title; there are "schools" or "departments" of engineering with and without mining. There are engineering "colleges" which are parts of universities and some which stand for nearly the entire university. Doubtless, such inconsistency will remain, but it deserves passing notice.

If we are to bring any large extent of industrial education within our purview, it is a fair suggestion whether our title might not better be: Society for the

Promotion of Technical Education. But let us rather consider that our past history and present aims are better expressed by the term Engineering Education. In that case we understand that "engineering" includes "technical," so far as that designates what makes for the professional endowment of the man; and that *education* includes *training,* as the whole includes a part, only without neglect of the broader culture, and without too much emphasis upon mere drill and manual dexterity.

A factor of efficiency, whether in mechanics or education, is a product of other factors, usually of many. The effectiveness of engineering education is greatly influenced and determined by the *purpose* in view, the *personnel,* both of teachers and taught, the *substance* and *methods,* the *machinery* and the *cost.*

First, as to the *purpose.* Much waste of educational effort results from indefinite aim. In the public schools, while studies are in some degree adapted to an end, that end is often very general rather than specific. Children are judged too much by the standards of maturity; "systems" and "methods," carried to excess, hamper both scholar and teacher. There are too many educational fads and experiments. Results are good—better than we might expect—but it is a familiar remark that one, two or more years were spent in school to little purpose, and that misplaced studies were pursued with small profit. Such incomplete results are often the fault of the pupils, but in the academies and high schools, preparation for college leads to more definite and effective work by the more ambitious. Education being so great a boon, it is argued that everybody should have something that goes by that name; but it is too often regarded as an end in itself rather than a means; else we should hear less about a "finished education."

The best examples we have of a definite purpose realized with a high factor of efficiency are the military and naval academies of the United States. These give the extreme type of *training*—drill and rigid discipline. All studies and exercises and nearly every circumstance of daily life are reduced to a prescribed routine arranged with sole reference to one object, viz: to raise up a body of officers fitted to command men and capable, in a great emergency, of organizing the volunteer forces of the army and navy for effective service. During the last years of the late Gen. Sylvanus Thayer, the writer had the privilege of hearing from the lips of that great organizer and model Superintendent of the Military Academy, statements of his policy and methods. Efficiency has been attained and maintained by strict discipline, involving close supervision of the life of the cadet, and the impartial infliction of sure penalty for every transgression; the assignment of the maximum of time to studies, drills and manly exercise; the cultivation of the spirit of obedience, truthfulness and devotion to duty; and the rating of men strictly according to merit. The best are qualified to enter any arm of the service, and those rated among the lowest can serve well in the artillery, cavalry or infantry. Here we have the perfection of training—the broader education lacking except in those who had previous opportunities before entrance. The recent celebration of the Centennial of the Military Academy has brought forth such general and authoritative testimony as to its work and worth that we can add nothing here.

But our engineering institutions generally do not have an aim so single and cannot so well control all of the conditions necessary to realize it. Yet if *requirements* for *graduation* were in all cases clearly defined and specified, and adequate tests impartially applied, a more distinct goal would invite all alike, and this factor of specific *purpose* would have its highest value. How well this goal is now defined may appear by looking over half a hundred catalogues and prospectuses of engineering colleges, and then considering the different careers of young men within ten years after graduation. We find some difficulties and inconsistencies in the various differentiations between civil, mechanical, mining, municipal, sanitary, etc., engineering. Electrical engineering is distinct enough. We cannot avoid the question whether there is not a little too much straining for divergence; whether we cannot better prepare for the inevitable divergence outside the college precincts, by promoting more unity within; whether either one of two or three inclusive *degrees,* well earned, have not more weight and value than the various and separating degrees now proposed in some quarters.

The right pursuit of a given end is largely determined by the element of time. Many are unwilling, or think they are unable to take time enough. The complaint is made that the raising of requirements of admission defers too long the entrance into practice. But Dean Wright, of Yale University, has shown in his last report that the average age of Yale graduates has increased during the past forty years only about four months. And this in spite of the fact that Yale maintains the traditional four years' course, that the college courses have been much strengthened, and that, by the Dean's estimate, the time needed for college preparation has increased from one and a half to two years during the twelve years just past. The editor of a leading New York paper, in commenting upon this, remarked that it is wrong to blame the college for a late start in life, because the professional schools are the real exactors. He says: "But some one will say that the professional training cannot be cut down. The non-practical, general education must be sacrificed to the requirements of the specialist. If a year or two have been added to the requirements of the graduate school they must be cut off from those of the academy and college. Very well. If that is the situation let it be avowed frankly. Let it be said that the pressure of American life is such that young men cannot be allowed to take the same time as their fathers for the training of character and the acquirement of culture. Instead of complaining that the colleges are laying new and unreasonable burdens on youth, it should be admitted that youth can no longer give time to the colleges. That brings fairly to an issue the question whether college—that is, general culture—is worth while, and if it is not worth while for a certain class of professional students arrangements can be made for omitting it."

Certainly this view is substantially correct. But any discussion must recognize the fact that college courses are not made effective enough even for culture. We know that hundreds, if not thousands, of students in college have very indefinite aims, or none at all. We know that too many distractions are allowed. Athletics—not the reasonable and necessary, but the peripatetic athletics, "society" claims, glee-clubs, dramatic clubs and a dozen wholly irrelevant activities, disorganize the legitimate work of the student. As a step toward promoting greater efficiency of the entire scheme we have seen the gradual acceptance, where the old-time college is concerned, of distinct professional courses made as nearly post-graduate as possible. By proper selection of college courses the earnest student can gain in three years practically as much for general culture as the ordinary man usually secured in four, by the old procedure. Two years of professional study—provided so-called "vacations" are also utilized—will then usually suffice. The writer may be pardoned for alluding to the fact of his experience with this arrangement for more than twenty-five years. During the period when men took four years in college and two in the post-graduate course the average age of graduates was quite a little beyond twenty-four years. During the last ten years, under the better system, the average age of graduates has decreased considerably more than a year. There is a feeling that we do not get men of so good all-around ability as formerly, but just comparisons are hardly possible.

Second, Personnel.—A former president of our Society has reminded us that the members should esteem themselves primarily as teachers. Admitting the desirability, or, if you please, the necessity, that a teacher of engineering should be or should have been also a practitioner, yet there must be above all a well-marked ability to teach. A good teacher who has had no practice (if such be possible), having the so-called ''genius'' for teaching, ought to be more effective than the practitioner who cannot properly impart his knowledge (for the latter we know to be possible). But let us remember also that we are not pedagogues simply, but teachers of *engineering.* We should be more identified with engineers than with teachers, since a good proportion of us are in professional practice. Therefore, our Society affiliations should not be with educational associations but with societies of engineers. The benefits derivable from the former are less serviceable to us than the opportunities and inspirations afforded by the latter.

The efficient teacher will ever lead forward; he will give inspiration and direction; to this end he must know the character and quality of each of his students; personal contact, without undue familiarity, is essential; the power of the instructor is not based alone upon professional attainments; mutual respect, mutual confidence and sympathy are necessary factors. The forceful teacher who gains such control will do more than direct and instruct—he will command. A little more of the arbitrary tone of West Point and Annapolis—something of the *weight* of authority—is needed; but to be effective must be backed by a personality which commands entire respect, and exacts cheerful compliance. Insubordination cannot be tolerated for an instant. Disobedience may be as fatal "on the works" as in the army. The habit of obedience must be formed in the student.

The personnel of the student body is one of the largest factors of our large problem. Lieut. Gen. Schofield, in a recent address to the alumni of the U. S. Military Academy, said: "The corps of cadets has always been a real American aristocracy—an aristocracy of character. If the time ever comes when competitive examinations or school certificates are permitted to take the place of established character, serious injury will be done to the corps of cadets and to the Army. The honor, as officers and gentlemen, of which cadets have justly been proud, is very largely in their own keeping. It is greatly to be hoped that the appointing power will do nothing to diminish the purity of this fountain of honor, which comes direct from what is best and purest in the country, the respectable family."

We would determine the qualities of our student material by our requirements for admission. But this is only an academic, or—if you please—a mechanical test. We recognize the quality of character and inherited traits as of greater importance. "Blood tells." If unsullied honor and unquestioned integrity are expected in the cadet or officer, much more should these virtues characterize the engineer. Hence, with all our requirements we must require the highest character. All our constructions must conform strictly to the principles and conditions which nature imposes; he who violates her laws, whether through ignorance or carelessness or guilty intent, cannot escape her penalties. A deceitful, dishonest or unreliable engineer is a *traitor* to a profession whose ideal of truth is exactness, whose standard of performance is uprightness and wholeness, whose symbols are the plumb, compass and level. Our engineering colleges must not fail to nurture the heartiest esprit du corps, or to exclude any who are not entirely trustworthy.

Third: Efficiency as determined by the *substance* and *methods* of instruction. How much and how? This ever-present issue, although well discussed last year, is still on the program. The last word cannot be said while conditions change so rapidly. It is not proposed here to dwell in detail upon the departments of instruction. That has been done in our previous consideration of *requirements for graduation,* which we are about to discuss further. It is already suggested that the right principle of selection and limitation of subjects is found just here. In this age of huge construction, the limits of which are yet indeterminate, one-hundred-ton locomotives, forty-million-gallon pumping engines, power plants with 8,000 and 10,000 horse-power units, gigantic buildings which descend into profound depths and tower high into the heavens, and other things we brag of, no longer astonish us. The great corporations in the business world, the vast and complex organizations for the government and misgovernment of a long-suffering and easy-going public, and all the various forms of trusts, are portentous realities. The thoughtful educator is compelled to pause and adjust himself and his work to this prodigious scale of activity. The vastness of many undertakings raises the question whether human capacity is adequate to manage them wisely and successfully; whether anything short of omniscient intelligence can grasp so many and intricate relations and interests, and keep them in adjustment.

Fifty years ago the legacy from the past to the few engineering students was small; the printed body of recorded practice was meager. The instructors of that day could be deliberate; they revelled in mathematical theory; they incurred the odium of being impractical. At the beginning of the twentieth century the multitude of students look to the engineering schools and colleges to put them in possession of an inheritance almost too large to grasp, and ever increasing. The school or college of to-day, with too little time at command, must do a much larger work with far greater intensity; therefore, it must be a more *powerful* agency. But it is still in the same relative place at the bottom of the professional structure. When we tear down the big building of our fathers to build the monster of to-day, we simply go deeper, make a broader and firmer foundation, and replace the bulkier brick with the stronger steel, so that all may be proportionate to the greater weights to be borne.

So in regard to the substance of instruction, let not the aspect of magnitude tempt us to get too far above the foundations. In almost every one of the special lines of modern engineering practice the graduate must serve as an apprentice before he is competent to take much responsibility. The exceptions to this are rare. Let the subjects taught be so primary and fundamental, and so thoroughly mastered, that nothing will have to be unlearned, and that the period of apprenticeship will be short.

The effectiveness of the total result will be increased by giving due attention to the historical background. An engineer may be a good enough tool to design and execute works, with but little knowledge of the history and biography of his profession. But if he is to have the wider horizon and large mental grasp, he should begin while a student to acquaint himself with the great fraternity of engineers, and be informed as to the lives and works of those who have made the profession.

The range of primary and essential topics is now so much greater than formerly that we have no room for non-essentials. The *principle* of *concentration* determines efficiency. Some present tendencies do not conform to this principle. For example, many books for instruction are too bulky and too diffuse; they are treatises rather than effective text-books. We have not simply an embarrassment but a flood of riches, in a vast accumulation of data and newly developed theory, from which it is difficult to make a wise selection; definitions and primary concepts need more emphasis and iteration than statistics and details; the student must quickly learn to think and discriminate for himself, while his *tasks* should relate chiefly to *that which he must learn,* being yet a student. The evils from the *forcing process* in education are everywhere apparent. The injury is equally serious whether we overtax the eager ones or overload those whom we have to urge.

The efficiency of instruction at our national academies has been attributed to the blackboard system. This includes daily recitation from a text-book, with a blackboard demonstration; sections of the class limited to ten or twelve, and each recitation a possible cross-examination; lectures are rarely given; eight or ten advance lessons are followed by four or five in review, and a general review precedes the subject examination, thus giving the proper repetition which is an element of good teaching. The semi-annual examinations are held before the entire academic board, for the most part, and for the rest, before two divisions of it; these are principally oral and by demonstration at the blackboard. When pushed to extremes this method leads to too much effort in preparing the lesson for *recitation* only; there may be more anxiety as to class standing than concern to gain the right mastery of the subject. But it holds the men to their work, and the shirk cannot escape detection. Indeed, this method promotes efficiency of effort on both sides; it gives the frequent contact; rightly managed it gives free scope to individual capacity and the possibility of a correct judgment of each student; there is a constant observation and test of progress. But if the instructor instructs too much his efficiency is gone. What the student really gains, "to have and to hold," he must always get by his own hard study of the book or of full notes, and by hard thinking. It is so easy and often so pleasant to talk to a class, that the teacher may forget that his primary duty is to learn what each man knows of the subject; to explain only what the student cannot himself ascertain; to detect and correct erroneous ideas rather than lecture to a half-attentive class; to create the appetite rather than administer excess of food; to develop and nurture the implanted germ rather than force the plant by too many external applications. Disappointment and chagrin at the small results from well-prepared class-room talks and lectures is a too common experience of all who try to instruct.

Of equal importance with the principle of concentration is that of *coördination* of subjects. This applies not only to the proper sequence of studies but to the quantity. The impairment of efficiency by ill-judged arrangement is self-evident; but we see also much harm done by the exaggeration of some subjects at the expense of others. All are not equally important, and if there is not a wise adjustment adapted to a definite end, the efficiency of the course as a whole must suffer. Here is where certain schools which we have discussed both succeed and fail. The restaurant plan of education allows a clear-headed man, handicapped by his wage-earning duty, to work with singleness of purpose and good success for a definite though usually narrow end; many do this quite efficiently. But a scheme of instruction adapted to all the requirements of to-day must be so comprehensive and well-proportioned that the immediate and continuous attention of the student can be given with the greatest economy of time, effort and cost. This means that the *choices* allowed to students should be few, since the inexperienced are seldom able to choose wisely for themselves. They should be restricted, in the well-balanced curriculum, to the few courses in which the studies are entirely adapted to ends clearly defined.

But proper coördination also requires continuity. It is a disadvantage, however excused or explained, that preparatory studies and culture studies are too much sandwiched with engineering studies and practices. It is true that a proper adjustment may mitigate the evil in the earlier years. But the practice is opposed to the principle of concentration, especially in the later years when the interest centers on correlated branches of engineering, for which more undivided attention is needed.

Fourth: Machinery as related to efficiency in engineering education includes all instruments, apparatus, machines, engines, models, etc. In looking at the now abundant equipment of our colleges we make at once a natural division into those without which effective instruction cannot be given, those which are desirable but not necessary, and those which are superfluous, if not indeed burdensome. If we should attempt to get an agreement right here as to what these several divisions should include, we should probably fail. It is said that a good workman is one who can do good work with poor tools. The history of engineering education gives conspicuous proof of this in the days of small things. But *efficiency* of operation is possible only with the best tools that can be had. The secret of the astonishing success of the great American engineering industries lies in sending even good tools and costly machinery to the scrap-heap, as soon as better have been devised. Efficiency is determined by sufficient every-day exercises, with due regard to proper limitations of accuracy. Instruments necessary for the precise work of the Coast and Geodetic

Survey are not within the scope of suitable practice in the school of engineering. The same principle applies equally in all departments. There is little enough time to acquire familiarity and facility with apparatus and machines of fundamental utility, whether in the field or shop. If an institution proposes to maintain a complete testing laboratory for mechanical or other tests of materials, an equipment of large and expensive machines may be justified. But for the *legitimate purpose of instruction* a few machines of moderate size, which the students can operate for themselves, is the most useful and effective plant.

Little need be said about apparatus simply desirable but not necessary. At best it serves for purposes of illustration. In this category may be included nearly all models which make the stock in trade of dealers, and many that are made by students. Their value is temporary; they accumulate; they are put aside into a store-room or museum. Lessons may be found, it is true, in museums and scrap-heaps; but interest in such collections soon wanes, and, after a while, they serve chiefly as vouchers for ineffective expenditure.

As to what machinery and engines would be considered superfluous in the colleges is a question provocative of lively discussion. If research, more or less extensive, is to be generally recognized as a function of the engineering college or university, then a plant of almost any magnitude or cost may be justified. But whatever advantages accrue to the profession from such establishments, they must be considered to be exceptional institutions. Their use for *instruction* to the body of students is and must ever be quite limited. Their efficiency in the general scheme is small in proportion to magnitude, initial cost and cost of operation.

Fifth: In all modern engineering operations, especially in the United States, a prime criterion of efficiency is cost. The annual appropriations for our national military and naval schools represent the interest of a principal for greater than the endowment of any American university. Yet we often hear the statement that they are worth all they have cost. Whether our Committee on Statistics will succeed in figuring the dollar-cost per graduate from our different institutions is a doubtful question. It is certain that the highest efficiency is not determined by the largest endowments or the most extensive equipments. If we could have ideal students working with ideal instructors, both would use a minimum equipment to the best advantage. The cost factor is so intimately combined with other factors that it cannot be easily separated. A sufficient endowment, which would render an institution entirely indifferent to income from students, would greatly simplify the problem. Classes could be limited by stricter standards of merit only. Large classes usually mean inadequate teaching force, with all the conditions of lessened efficiency which that implies. Again, the final estimate of the cost goes beyond the money outlay, and cannot be made until the professional development of the man is in evidence. There is an obvious tendency towards some extravagance in buildings and equipment. The ideas of an expensive architect are sometimes allowed to govern, when an engineer would secure the maximum of utility at far less cost. The disposition in some quarters to put too much of large endowments into buildings lessens the funds for providing the maximum man-power, without which a grand structural plant is of small account. Hesitation to pay the full price for the best instruction is fatal and mistaken economy. The principle here is: good men at any price; a good plant at the least cost consistent with utility.

These random reflections, pertinent and impertinent to some of the live questions before us, may appear to partake of the indefiniteness of the subject of the discourse. While the coefficient of efficiency in this connection is indefinable, it would appear that we are giving some degree of determinateness to the elements; the ideal education or standard itself is becoming better defined; our average and maximum outcome is better than ever before, and evidences multiply that the resulting ratio is reaching a higher value. To this end we have seen the importance of having a well-determined purpose kept clearly in view. We have appreciated the testing of the personnel by qualities of character and professional adaptation, which should produce that strong reaction between teacher and taught which will maintain enthusiasm, and confer such power of knowledge and strength of personality as will be most effective in the graduate. We are reminded how much depends upon the subjects and methods of instruction, their selection and effective coördination, and the value of continuity and concentration. And, finally, we would be governed by the prime principle of the engineering profession, to wit: to derive the largest and best output possible from the judicious expenditure of money and labor.

THE VALUE OF NON-RESIDENT LECTURES ON ENGINEERING SUBJECTS.

BY WILLIAM D. PENCE,
Professor of Civil Engineering, Purdue University.

In view of the long-continued custom of calling in non-resident specialists to deliver lectures at most engineering schools of importance, it must be concluded that the general opinion as to the merits of the plan is, on the whole, a favorable one. The arguments in favor of the practice, as they appear to me, are as follows:

1. The student is impressed by the personality of the lecturer, perhaps more than by the things that he may say, with the result that a finer spirit is instilled and a better point of view developed in the individual student. This is really the highest function of the lecture by the non-resident specialist, and it is also the point in which most lecturers or teachers, resident or non-resident, are prone to fail. However, the value of this service is so real that the plan under discussion is fully justified even if the notable successes in this first particular are only occasional.

2. The student's point of view in a technical sense is broadened, especially where the lectures are varied and are delivered before an assemblage of students from the several departments of engineering, as is the practice at various technical schools. This point is of particular importance in these days when specialization is so sharp in our technical courses that no student

gets very much of an insight into the lines of study outside of his regular schedule.

3. Purely technical lectures by specialists of known skill and widely established reputation serve to amplify points which have perhaps scarcely been referred to, or at most have received only incidental treatment, in the regular course of study. Such lectures may often be imperfectly appreciated by the student owing to his lack of preparation, but they illustrate to him the necessity of being thorough, accurate and untiring in his work.

4. The members of the local faculty should have nearly as much interest in lectures by non-resident experts as should the students themselves, and with their broader point of view they should gain more direct benefit. It is nowadays demanded of the engineering educator, not only that he keep abreast of the times in his particular line of work, but that he cultivate more or less direct contact with those engaged in active professional practice. The teacher is busily engrossed with his pedagogical duties during the greater part of the year, so that he should be ready to profit by these opportunities which come directly to his door.

5. The fifth and last advantage which I will mention is the advertising value for the institution itself, in calling in eminent men to lecture to its student body. This advantage is mutual, for not only does the institution gain friends, but the lecturer invariably receives a strong stimulus from his occasional contact with an audience of alert young men.

Referring briefly to the other side of the question, I should say that there is often a real danger that the student may come to look upon these lectures as occasions when he may let down, so to speak. Perhaps the recent tendency to the inordinate use of the lantern has led the student to expect a picture show from every lecturer. No sensible person would question the high value of the stereopticon as an aid to lecture work, but its excessive use has undoubtedly led to abuses.

Like any other good thing, I suppose that the non-resident lecture system might be overdone, but I have never had an opportunity to observe such an abuse, and so cannot comment upon it intelligently.

As to the relative merits of a single lecture and a series of lectures by the same man, it may be said that the decision hinges largely on the ability of the man to tell his story in a single hour. There are plenty of men who have more than enough to occupy the time for a long series of lectures, but who, unfortunately, lack the power to tell what they know before a formal body, especially when that body is as critical as the college student is commonly alleged to be. Another point which must have first consideration in this connection is the one of finances. Given the proper man and the necessary means to get him, there are undisputed arguments in favor of the plan of giving these engineering lectures by series, at least in part.

In choosing lecturers every care should be taken to find men who will appeal in a personal way to the student body. If the student can be helped to look upon the eminent engineer who lectures to him as representing an ideal that he may ultimately attain to, this lecture system becomes a very important part in making the man and the engineer at the same time. In this connection reference may be made to the especial advantage possessed by those older technical schools which may draw upon a list of distinguished alumni in selecting their lecturers.

BY GEORGE F. SWAIN,
Professor of Civil Engineering, Massachusetts Institute of Technology.

Non-resident lectures on engineering subjects may be considered to be valuable in three ways: (1) As an actual means of education to the students; (2) as affording inspiration and suggestion to them; (3) as a means of advertising for the institution. I will briefly consider the subject from these three points of view.

1. As a Means of Education.

In my opinion the educational value of non-resident lectures is, as a general rule, small. This depends, however, to a certain degree, upon the lecturer himself and the degree of his appreciation of the needs of education, and upon the experience, training and teaching capacity of the regular staff of instruction in the institution.

It must not be forgotten also that what the students in our engineering schools need is a thorough training in principles and not a discussion of practical details, except so far as is necessary to enforce and illustrate the application of those principles. Practical details the student will learn after he leaves the school, but principles he is much less likely to learn; and unless he leaves the school thoroughly grounded in them, and with the capacity for study and investigation, he will be very apt to make no progress in mastering them. I do not mean to say that no practical details should be taught in the school; but what I mean to emphasize is that the main stress should be laid upon the study of principles, enforced and illustrated as amply as is considered necessary for thoroughly mastering them, and that the time is too short to enter largely into the study of practical details, which, if the principles are thoroughly understood, can be easily read up by the student after he leaves the school. The average student in an engineering school is not able to appreciate a discussion of practical details, the final result of which depends upon experience, and is the result of the experience of many engineers throughout many years.

If the regular staff of instruction consists of men who are in touch with outside engineering work, who have had experience themselves, and who are able to appreciate the practical as well as the theoretical point of view, I believe there is little or no need, from the purely educational standpoint, for such men to call in outside lecturers to any considerable extent. They will themselves be able, in my opinion, to arrange a course of study and to combine the theoretical and the practical instruction in such a way as to produce the best results without outside assistance.

Practising engineers, even though eminent in their profession, if they have had no experience in teaching, have frequently, according to my experience, little conception of the needs of the student, and are not able to put themselves in his place and to arrange a lecture which will be of permanent benefit to him. They frequently talk to classes of students in the same way that they would talk to a society of engineers of experience, and much of what they say fails of appreciation. It is good material largely thrown away, and is more suited to a meeting of engineers than to a college course.

Under such circumstances, outside lectures are more in the nature of a recreation than a serious study. It is very interesting for a student to hear a good description of some important engineering work that is being carried on, and a relation of the difficulties which were encountered, a discussion of the relative merits of the different routes for an inter-oceanic canal, or a series of illustrations with reference to different methods of carrying on work of a certain kind. All this may be, as I have said, extremely interesting, but yet, on account of the immaturity of the students and their own lack of experience, is, in my opinion, of little real educational value to them. This brings us to the second point of view.

2. As a Means of Inspiration and Suggestion to the Student.

From this point of view these lectures are, in my opinion, of considerable value. They should, however, be judiciously selected and arranged, and the number should depend upon the ability of the regular staff of instruction to furnish such inspiration and suggestion from their own experience without outside assistance. If a professor of engineering is a purely theoretical man whose knowledge comes entirely from books, and is known by the students to come entirely from books, the interest of the students in their work will be largely enhanced if they can occasionally hear a lecture from an outside engineer whose knowledge comes largely from experience. It is, moreover, always an inspiration for students to see and hear men of whom they read and who have attained to eminence, whether they are engineers or members of other professions. From this point of view, then, I believe outside lectures to be of value, but it is easy to go too far and by having too many of them to make the students lose a due sense of the necessity of the thorough study of principles, and to make them more interested in the practical details than in what should be their real hard work at the school.

3. As a Means of Advertising.

I believe that outside lectures are valuable to an institution to a certain extent as a means of keeping the school in touch with practicing engineers, and as a means of showing a certain number of engineers each year what the school is doing, and gaining their interest and good will. This is a matter which must not be lost sight of, and is a perfectly legitimate object to have in mind. The schools are factories where engineers are made; there must be harmony and co-operation between the schools and the engineering profession. Engineers must not be allowed to rest in the belief that the schools teach theory alone, or that they stand off by themselves and do not seek the support of the profession. It is equally justifiable for an institution to bring in outside lecturers purely as a means of gaining their interest and support, and for such engineers to be elected to the governing boards of such institutions. In closing I may say that in the department of civil engineering at the Massachusetts Institute of Technology all of the professors are men who have had practical experience and who are in active practice to-day to as great an extent as their duties at the Institute will allow. The younger men in the department are also encouraged, and it may almost be said required, to spend their summers, or at least some portion of their summers, in practical work. Under these circumstances, outside lectures are in no sense necessary from an educational point of view. It is solely from the other two points of view that they are considered of value, and the number of such lectures delivered specifically before the civil engineers is comparatively small. Students in the Institute, however, have an opportunity to hear a great many lectures of this kind by attending the meetings of the Society of Arts, which is an engineering society whose membership is made up of gentlemen in business and in the professions who are interested in technical matters, as well as of teachers at the Institute, and which holds meetings twice a month. During the year, therefore, there are sixteen lectures before this society by outside engineers or professional men of eminence.

During the yast year the lectures before the Society of Arts have been as follows:

"The Olympia: A General Description of this Famous Ship, and a Discussion of the Development of

Cruisers during the Past and the Tendency to Future Progress.'' Naval Constructor William J. Baxter, U.S.N.

''Present Condition of American Railroads as Compared with the Period of Depression 1893–1897.'' Professor William Z. Ripley, Expert Agent on Transportation, U. S. Industrial Commission.

''The Importance of Catalytic Agents in Chemical Processes.'' Professor Arthur A. Noyes.

''The Development of the Nernst Lamp in America.'' Mr. Alex. J. Wurst, Manager Nernst Lamp Company.

''The Development of Locomotive Boilers with Particular Reference to the Vanderbilt Boilers.'' Mr. Cornelius Vanderbilt.

''The New Star in Perseus.'' Professor George E. Hale, Director Yerkes Observatory.

''Utilization of Electricity in Mines.'' Mr. Calvin W. Rice, Electrician, New York Edison Company.

''Some Features of the Isthmian Canal Question.'' Professor W. H. Burr, Member U. S. Commission on the Isthmian Canal.

''Engineering in China.'' Mr. William Barclay Parsons, Chief Engineer, New York Subway.

''Aluminum as a Reducing and a Heat-producing Agent.'' Professor Heinrich O. Hofman.

''India Rubber: a Description of the Crude Gum and its Manufacture.'' Mr. Walter E. Piper, Assistant Superintendent, Boston Rubber Shoe Company.

''Smoke and its Abatement in Large Cities.'' Professor C. H. Benjamin, Supervising Engineer, City of Cleveland, Ohio.

''A Trip through Siberia.'' Hon. E. J. Hill, Member House of Representatives, U. S.

"Success in Long-distance Power Transmissions." Dr. F. A. C. Perrine, President of the Stanley Electric Manufacturing Company.

In addition to these, there are perhaps, on an average, a half-dozen outside lectures each year given specifically before the civil engineering students. Further, mention should be made of a series of short talks, of about twenty minutes each, given before all the students of the Institute by eminent men. During the past year talks of this kind have been given by Dr. Edward Everett Hale, Booker T. Washington, President Eliot of Harvard, President Hadley of Yale, M. Leopold Mabilleau, and Col. Thomas Wentworth Higginson.

Finally there is a fourth class of outside lectures given before the Civil Engineering Society, a society to which all students in civil engineering are eligible. During the past year these lectures by outsiders have been as follows:

"Some Peculiar Variations of the Magnetic Needle Observed in Alaska." Dr. H. S. Pritchett.

"The Institute Eclipse Expedition to Sumatra." Mr. G. E. Hosmer.

"The Relations of Contractor and Engineer." Mr. C. W. Flannery and Mr. C. B. Breed.

"The Summer School of 1901." Mr. George T. Seabury.

"Jupiter as a Comet Catcher." Mr. Percival Lowell.

"The Use of the Stadia for Precise Measurements."

"A Plane Table Survey in the Adirondacks." Mr. G. E. Hosmer and Mr. S. L. Wonson.

"The Work of the Hydrographic Department of the U. S. Geological Survey." Mr. F. H. Newell.

"Arizona and the Grand Cañon of the Colorado." Mr. H. K. Burrison.

"The Cambridge Bridge." Mr. F. H. Fay.

It will thus be seen that in this institution there is a large provision for outside lectures, but that the last three classes—that is to say, the lectures before the Society of Arts, before the Civil Engineering Society, and the short talks by eminent men—are entirely optional and are in the nature of engineering recreation rather than in the nature of prescribed work. The number of outside lectures which students are required to attend do not number more than a half-dozen each year.

BY ROBERT H. THURSTON,

Director of Sibley College, Cornell University.

In the organization of the Sibley College of Mechanical Engineering, at Cornell University, the writer was authorized by the trustees of that Institution to take such a course in the organization and administration of the college and its attached schools of mechanical engineering as might be found advisable. The purpose was to build up a professional school of the first rank, under the statutes of the United States, of the state of New York and of the university, providing for the "leading objects" in promotion of which the land-grant colleges of the several states were especially founded. The United States law conveying public lands to such states and their colleges made the stipulation that, in these colleges, "the leading object" should be "to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislature of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."*

Under this provision, the organization of Cornell University has been established and within the university are included Colleges of Engineering, Architecture, Agriculture and Forestry; while the schools of medicine include a College of Veterinary Science. The College of Mechanical Engineering and that of Civil Engineering are independently organized and all these colleges, and that of Arts and Sciences, the academic division of the university, as well, give mutual aid, so far as practicable.

The curriculum of each college is especially constructed for its own professional work but, necessarily all depend upon a fundamental basis of mathematical, physical and chemical sciences, which studies in pure science are conducted in the academic branch of the institution. Their curricula have the same general form as similar schools and colleges elsewhere, except that, under the pressure of natural development, they have usually come to be more purely professional than is usual in this country, their students often including considerable numbers of graduates of other colleges of the university and elsewhere. In numbers, they are also exceptionally extensive; Sibley College to-day registering about 800 students in all schools, departments and courses and, of late years, graduating from 100 to 125, annually. The college faculty consists of some forty professors, instructors and other teachers, and a corps of non-resident expert lecturers who visit the college more or less regularly to discuss and to illustrate the latest progress in their particular fields of engineering practice.* Of these the number is variable from year to year, but commonly from six or eight to ten or twelve, all leaders in their respective specialties, who present their summaries of progress and exhibit its trend in the later developments of their departments.

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* U. S. Statutes, July 2, 1862.

There were many reasons for the adoption of this system. The primary purpose was an obvious one: securing a statement, from the expert most familiar with the subject discussed, of the state of the art in its most perfected example and most authoritatively. Other aims were the finding out, through such authoritative exposition of what at the moment is the trend of progress and what the momentary, or possibly ultimate, limitations to further advance as they appear to the best-informed members of the profession; learning the details of construction of the most remarkable products of modern engineering and of the productive industries; ascertaining what are the relations, in the manufacturing industries, between the elements of the organization, capital, skill and labor, between the industry and the market, the industries and the country or the foreign markets.

Perhaps a hardly less important point was that of presenting to the novices of the profession the famous men in whose footsteps they expect, later, to follow, to show them what manner of man takes a position in the van; giving the youth of the profession an opportunity to see and judge and study the great practitioners. On the other hand, it is a most desirable thing that the influential and leading men of the profession should understand what the technical schools and colleges are about, and how they seek to attain their ends; the result being anticipated that each will do the better work with and for the other, that the men may know the schools and the schools the men; that each may help the other to perfect the methods of the profession, to introduce, more and more thoroughly, the exact methods of science where they find proper place and use and, finally, to bring to the teachers of the science of the profession something of the practitioner's side and to give both the power, in higher degree, of uniting, most completely and fruitfully, science and art.

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* All mathematics, languages and pure sciences are taught in the University.

All these purposes have been, in the experience of the writer, most admirably accomplished and with mutual advantage to school and professional practitioner. This mutual acquaintance of the representatives of the profession and of its schools is perhaps the largest result accomplished after all. It gives each an intelligent and cordial interest in the other, secures kindly criticism from those who—apart from their misfortune, usually, of themselves lacking such scientific preparation and systematic training for their work in life—have the greatest competency and the largest influence. It awakens their interest not only in the schools, but especially in the young man coming from the schools, and the latter finds a most helpful and genuine friend where he most needs one.

One of the most difficult and long-drawn-out tasks of the professional, and especially of the engineering, schools, in the generation just past, has been that of removing the prejudice of the profession, and especially of the business men, of the country against the graduates of the schools, however high their position or excellent their work. A generation ago it was very difficult to secure employment for the alumnus of the engineering school on any terms. He was looked upon as a very useless member of society, incapable of making himself a source of profit to the employer, finicky, conceited and impracticable. But this is not the attitude of employers to-day. The graduates of all efficient schools are now sought with eagerness by all great employers and organizers and the fact is now universally recognized that the man who adds to a good scientific and professional training a knowledge of his art, acquired by its practice, is a vastly more valuable man than any purely ''practical'' man possibly can be. The young men from the schools come into business with spirit, ambition and a determination to succeed and with perfect willingness to undertake any tasks, however disagreeable or difficult, and to thus perfect themselves by uniting the practical knowledge of their art, its practical superstructure, with its scientific foundation. In later competition, they possess the inestimable advantage of adding to all the experience and knowledge of the older sort of practitioner the systematic training for their profession and the scientific knowledge which the other type of man cannot possibly secure. When the opportunity comes, there is no question which is to secure the advantage; it will always be the man of largest and highest attainments.

In this change of attitude on the part of the employer, the expert lecturer, who has seen the school and is familiar, as is no other man, with the most perfected practice, has had a large part. He has been the intermediary, in large degree, between the school and the world of business.

Intercourse with the leaders of the profession, also, has its special advantage in aiding that change in the schools which has marked the last decade particularly—the introduction of methods of research and the elevation of departments to the dignity of producers of needed information, of contributors to the sum of professional knowledge. This is vastly more directly helpful to mankind than the greater part of the work of investigation in the pure sciences, and hence even more dignified and honorable. There are few ambitious and talented men in the profession to-day who do not find or make ways to conduct scientific investigations of the unsolved problems and unanswered questions of engineering and the applied sciences. The fundamental science of engineering has made more progress in the last score of years than in a century before and this has come, mainly, it may be safely asserted, from the closer union of the profession with its schools and of the stimulation of each by the other. The practitioner suggests problems demanding solution; the mechanical or physical or chemical laboratory furnish opportunity for their solution and the scientifically trained instructor, himself a practitioner, usually, performs the work.

Such contact between the schools and the profession gives mutual interest and mutual respect, permits thorough understanding of each by the other and leads to union for a common end, the advancement of the profession to higher dignities and larger usefulness. We find, by long experience, that the talk of the expert lecturer always fittingly supplements, and never supersedes or interferes with, the work of the faculty. Its tendency is, always and wholly, if properly adjusted to the scheme of the school, toward a higher and a better professional standard of instruction, of learning and of achievement. "In union is strength," and the most desirable of all forms of strength, and of the elements of stability, in engineering is the complete and effective union of science and art, through the harmonious coöperation of the schools and the professional.

When the inventor of the telephone meets a body of young men and tells them of his struggles and his strifes, of the development of his ideas, of their gradual crystallization into forms of metal and systems of intercommunication across continents, those young minds take a new attitude and afterward live upon a higher level. They recognize the human quality of the great inventor and see that, given natural adaptation to any work, industry, "steady thinking about things," as Isaac Newton would say, conscientious searching, will generally bring the work to a satisfactory fruition. When the builder of the original "high-speed" steam-engine tells of his change of profession because he felt that the years of his freshest manhood had been largely wasted through his error in first choice, and when he goes on to tell of his thoughtful study of the situation and his conclusion that a "high-speed engine" was needed to constitute the next step in advance, as an element of importance in the reduction of wastes, in the increase in economy of operation and in the lowering of costs; when his long seeking for a valve-gear, his perseverance in the face of prejudice, interested opposition and the at least passive resistance of the profession, until after a long struggle, that little engine at the International Exhibition in London, over forty years ago, compelled recognition of the new construction, and, finally, when he tells of the later discouragements which threw the machine practically out of the market more than once, only, each time, to be brought back by the brave inventor and pioneer, no young man—no old man, for that matter—can fail to gain, from the story and from the meeting with its relator, respect and admiration for the man, renewed confidence in the mission of the profession and greater courage and pluck and persistence and confidence in one's own work.

Non-resident lecturers, if of the right sort and discreetly selected to meet the requirements of the place and time, may do a great work and one which the resident lecturer cannot either perform or rival, even if he would. But this system reinforces and conspires with that of the curriculum and gives to the work of the permanent teacher a finish which it cannot otherwise by any possibility acquire. It is a strong and reliable link with the great world of the profession and is a fine introductory to the work which the young auditor must presently undertake in the great outside world, as well as an introduction to the men who make the profession honorable and respected throughout all civilized countries.

DISCUSSION.

PROFESSOR WOODWARD.—Professor Woodward had only a simple point to make: He explained that at Washington University the practice had obtained of occasional lectures from practising engineers, both graduates of the university and others, and they had been found very valuable, but that in his opinion there are points of danger in this practice. It is highly important that the men who come to give these lectures shall work in sympathy with, and with a knowledge of, the surroundings of the university. Assuming that the instruction is well planned and well given, it is important that the lecturer should not prejudice the students against the work they are getting day by day in the institution, by unduly magnifying other matters. Professor Woodward thought that the wise man would coöperate with those who are permanently carrying on the work of instruction. He went on to say that one young man told him that he had been invited by a students' club to give a talk on engineering matters, and that he was urged by the students to give them something of practice as they found they were getting plenty of theory. The lecturer took that very point as his text, telling the students that in assuming that their study of theory was relatively unimportant they were all wrong; he took exactly the ground taken by Professor Swain in his discussion of this question; that they must get those permanent principles, which do not change as the years roll on; that there is time enough to get the details of practice after the student leaves his institution; that although the student has the idea that he cannot get too much practice, the fact is that what he should seek is sound theory, and rely on later opportunities to get at the details.

Professor Woodward went on to say that he thought there was another good thing which comes from this plan, of an engineer's telling the story of his own success, and it is that the students find out that that success does not come by accident; that the lecturer is a great man in his profession by reason of hard work, study, observation, pluck; the students have learned a great thing when they have learned this lesson. Students sometimes have the idea that these things come by good fortune, good luck, but they learn from the engineer who has fought his way up to success that there is no easy road to eminence in engineering any more than in anything else.

Professor Woodward, in closing, wished to enforce his first idea in this discussion, that nothing should ever be done in the way of introducing new lecturers to give the impression that what the students are getting day after day, and week after week, is not, after all, the best that can be done for them.

PROFESSOR C. FRANK ALLEN.—Professor Allen brought out a point not mentioned in the papers, as to one form of fortunate result that had come from the work of outside lectures. He had known of cases where the lecturer did, as a matter of fact, take up the same subjects that had been treated by the professors in the class-rooms, giving, in that way, a substantial backing to the teaching that the students had received. In some cases it had seemed that the treatment of the subject given by the professor was better than that given by the outside lecturer, which was not unfortunate in its effect upon the student. Professor Allen, in answer to a question, said that, in his opinion, it was very difficult to tell what a man very well skilled in his work may do in the presentation of a subject in a lecture before a class; that a man like Col. Prout, who is in educational work all the time, will present before a class a subject in a way which certainly is not inferior to that in which any of our professors can be expected to present it; but that there are many able engineers in practice who do not have the faculty of presenting a subject in the right way, and it is impossible to tell definitely about this point in advance.

PROFESSOR EDDY.—Professor Eddy said that he had had an experience in getting a distinguished lecturer to give a lecture which was to occupy one hour, and the outcome was *three* lectures each one hour in length.

METHODS OF GRADING STUDENTS IN ENGINEERNG COLLEGES.

BY CHARLES P. MATTHEWS,
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La Fayette, Ind.

This paper is little more than a collection of answers to a set of about a dozen questions sent to various members of this Society for the purpose, chiefly, of ascertaining the extent and general character of the examination system of grading students.

In what follows the more important questions asked will appear, together with a brief summary of the answers received.

Answers to the general question, *Are final examinations held in your institution?* show that the plan of giving final examinations is almost universal in the engineering schools of this country. Out of twenty-one replies received, sixteen specify a system of examination governed by uniform university or college regulations, four specify departmental control while *one only* states that final examinations are prohibited by faculty rules. The grade of the student in this last instance is determined by term work conducted under the university restriction that no exercise, whether oral or written, shall have greater weight than another.

It may be said, in passing, that it is a matter of general experience that in lecture and other courses in which no weight is given to term exercises, students develop a tendency to neglect their work up to the time of the "cramming" period. On the other hand, the absence of a final examination is likely to develop facility in getting up the day's work and, in many cases, equal facility in forgetting it. Preparation for a final examination manifestly makes for a comprehensive grasp of the subject. A suitable combination of term and final grading would seem to be the best system.

To ascertain the extent of the practice of throwing the student upon his honor in examinations the question was asked, *Does the so-called "honor system" prevail in examinations in your institution?*

Specifically, the replies were: "Yes," four; "no," twelve; "to some extent," four. One reply was, "Not as practiced at the University of Virginia." Total, twenty-one. As this is quite as much a matter of ethics as of engineering education the speaker will refrain from any discussion of it here.

Replies to the question, *Are finals held at the close of term, at close of year or at close of the entire course?* specify the end of the term in twelve cases. In seven cases the matter is one of discretion with the head of the department. In only one case does the examination period come at the completion of the course in the institution.

What grade is necessary for passing? The speaker realizes that numerical grades do not, as a rule, mean much. One instructor's fifty per cent. may be more difficult to obtain than another's eighty per cent. If a problem correctly solved is worth one hundred and one totally wrong is worth zero, the question is, What is the worth of a partial solution? The judgment of different instructors will be found to vary widely in such matters. When, however, the preparation of questions and the grading of papers are taken up jointly by all members of the department, the question of the individual judgment of the instructor may be said largely to be equalized, if not eliminated. Twenty answers to the foregoing question may be classified as follows and taken for what they are worth:

Grade.	Answers.
80 per cent	1
75 " "	4
70 " "	2
62.5 " "	2
60 " "	5
50 " "	2
No uniform practice	4
Total	20

A similar lack of uniformity in the apportionment of credit between class and examination grades might have been expected. Replies to the question, *What weight is given to the class grade and what to the examination grade?* were as follows:

Ratio, Class 3: Examination 1	1
Class 2: Examination 1	4
Class 1: Examination 1	5
No uniform practice	10
Total	20

As to the exemption of students from examination in case of a term grade lying above a specified value, replies indicated the following:

Exemption	4
No exemption	7
At instructor's discretion	9
Total	20

The grades requisite for exemption range from 75 to 93 per cent., the preference being for 80 per cent.

The question, *Are laboratory courses supplemented by final examinations?* elicited replies as follows:

Yes	2
No	5
Miscellaneous replies such as: "Sometimes," "generally not," "usually," "not formally," "as a penalty for lax work and to clinch a failure"	13
	20

The following general question bearing upon laboratory methods was asked: *Are your laboratory, shop and drawing courses conducted upon the time basis* (*i. e., so many hours to be put in*) *or upon the achievement basis* (*i. e., so much work to be done*)*?*

Out of twenty-one replies to this question, four indicate a pure time basis, four a pure achievement basis and thirteen a combination of the two consisting usually of a specified number of hours with minimum allowable achievement.

In conclusion, a word or two may be said as to the relative merits of the time and work basis of conducting a laboratory, shop or drawing course. Where the pure time basis exists the equipment must be large and system somewhat elastic. A student has the right to ask for an immediate new assignment on the completion of an exercise. In laboratories with large set pieces of apparatus difficulty may be found in accommodating him. The speaker believes that physical and electrical laboratories, where much of the apparatus is small and interchangeable, and where duplication is often possible, are better capable of operation on this plan than mechanical laboratories, where many pieces are large and necessarily fixed. The good student, working on the time basis, will push each task to completion rapidly. The laggard will be concerned chiefly in scoring the required number of hours on the time sheet. Students working on the time basis will, in general, be required to write reports on the laboratory. This necessitates a reference library and other facilities.

DISCUSSION.

PROFESSOR CALDWELL.—Professor Caldwell said he would be glad to know if, with reference to requiring examinations, and grading during term, any members of the Society had had experience with a system which he had used in the last few years, namely that of holding the class responsible for an unannounced examination in all the work they had covered, at any time during the term. Professor Caldwell said it seemed rather a heroic method, and he had hesitated to try it until the alumni association of his institution had sent out some inquiries soliciting the opinions regarding examinations, and he was surprised at the large number of the alumni who considered these examinations desirable.

PROFESSOR C. M. WOODWARD.—Professor Woodward said that the practice at his institution was to make the examination one of power and ability, rather than to allow it to depend on memory. That is to say, the students are told to bring to the examination all the notes, books, etc., they wish, and to show what they are capable of doing.

Professor A. W. French.—Professor French said that the method of giving examinations unannounced had been tried by him for the past two years with great success. He said, further, that in making up the paper the condition of the student must be borne in mind, but that there are fundamental principles which a student must have clearly in mind in order to do good work, and the tests coming unannounced brought pressure upon the students to keep these working principles fresh in mind. Professor French said that the last speaker had touched on a very important subject, and that he had found that, under the conditions of giving the students all the books, notes, etc., they needed, they did very poorly, and that, in his opinion, a succession of tests in which they have all the notes they want opens their eyes to a good many things.

Professor Kingsbury.—Professor Kingsbury said he wished to corroborate what Professor French had said with reference to the value, or otherwise, of books to students in examination. He thought that the value of such aids is altogether mythical. If the student does not thoroughly know the subject he cannot use the book, and if he does know the subject the book is unnecessary.

Professor C. F. Allen.—Professor Allen said, with reference to the remarks of the last speaker, that, in that case, the students ought not to know beforehand that they are to have their books, and if that knowledge leads them to do bad work during the term it is very unfortunate. The purpose of the instruction is to train the men. The examination is only in part to find out what they know. The purpose of the examination is to compel the students to do good work, and any system which encourages them to neglect their work during the term is a bad system.

PROFESSOR FLATHER.—Professor Flather thought the plan suggested by Professor Caldwell is right; he had used it for ten years and the work had been eminently satisfactory: The men do not know when they are to have an examination and the result is that their daily work is kept up better, since they must be prepared for a quiz at any time. Professor Flather said that in some of the subjects the students were allowed to bring any material they wished into the final examination; that during the term, however, this is not permitted, since they are supposed to keep up with the daily work and the questions in the quizzes are of such a character as to test their general knowledge. But that at the end of the term, when the examination requires it, they may bring in their slide-rules, notebooks, or anything that will aid them to solve the problems to be given.

Immediately preceding this an examination is given, covering general principles and lasting for an hour and a half or two hours, in which the students are not allowed the use of the books at all.

The quizzes or tests are given at any time during the term, at intervals of from three to five weeks (not regular intervals, otherwise it would be easy to calculate for them), in a subject that occurs from three to five times a week; the speaker thought this method very satisfactory, and that it ought to be used in teaching many subjects, rather than to give set dates for examination, when the students know exactly when the examination is to come and make special preparation for it, often to the detriment of the daily work during the interim.

PROFESSOR HOWE.—Professor Howe said that at Case School of Applied Science the method spoken of by Professor C. M. Woodward had been in use in certain classes and in certain work. The examinations are of two kinds, those that refer to the theoretical side of the work, and those that refer purely to the practical work; in this latter case the students are always allowed their books, and the same helps that they would have as engineers. In regard to giving unannounced examinations, the speaker thought that, as a rule, these were not given at the Case School, but he was formerly in an institution where this was the only kind of examination that was given, and he had found that, although the examinations were unannounced, the tendency was to make them not as severe as they had been scheduled and the students had been given an opportunity to prepare for them.

PROFESSOR RAYMOND.—Professor Raymond said he fancied the times and character of the examinations ought to depend largely on the method of presenting the subject. A lecture course would require one sort of examination, a recitation course another, and at less frequent intervals. Professor Raymond said that at Troy the period is divided into three divisions; a given course proceeds with a recitation every day until the course is completed, and it may or may not occupy all of the time given up to advance work; it may be a course only two weeks long, or thirteen weeks long; but at the end of a certain time all advance work is stopped, and a period of review work is begun, which is likewise recitation work, during which the instructor does not explain very much. This review period is of such length as to permit one lesson or one exercise for each week in advance. At the end of this period examinations are held, and this occurs twice each year. The instructors differ as to the character of their examinations. Of course, where recitations are heard every day, it is not difficult to find out what a student knows, and students who have done very well are frequently passed with a nominal examination, largely oral. Oftentimes, too, there are written examinations of the kind described by Professor Flather—examinations in the morning in which no helps are allowed, and examinations in the afternoon, lasting, usually, all afternoon, in which all the helps desired are allowed.

LABORATORY NOTES AND REPORTS.

BY FRANCIS C. CALDWELL,
Professor of Electrical Engineering, Ohio State University.

This paper is written chiefly with the hope of developing some discussion upon the questions involved.

It would appear that relatively too much stress is often laid upon the shape in which laboratory notes are handed in, rather than upon the form in which they are taken down. My observations have led me to believe that the scientific departments are most often at fault in this, while on the other hand the civil engineers are the most exacting in their requirements with regard to original notes. It is of course well understood that the copying of notes adds to the chance for error, and that in legal cases the evidence of original notes is much more valuable than that of copies. In spite of this, however, we find students allowed to take their original notes in some cast-off note-book or even on scraps of paper, no attention at all being paid by the instructor to this material which is then carefully and neatly copied and handed in looking like exercises from a copy-book. This condition of affairs seems to be largely due to the idea that neatness is a predominant virtue and that it cannot be obtained in sufficient degree in note-books used in the laboratory. Both of these propositions may well be disputed. Neatness should be insisted upon, but it is in the taking down of the notes that it is most important, and nothing is so little calculated to encourage neatness at this point as the idea that the notes are to be copied, and the original ones discarded and perhaps even thrown away. It is furthermore surprising what a considerable degree of neatness can be obtained in note-books used in the laboratory, even when heavy machinery is being tested, if only sufficient stress is laid upon the necessity for it. Some pains, however, must be taken to make the conditions as favorable as possible to neatness, and one of the most important of these is the kind of note-book used. As a general thing if left to his own devices the average student may be relied upon to get a note-book which lends itself with the least grace possible to high standards of neatness. With him the largest number of pages for a nickel is generally the test for a good note-book, and the result will usually look shabby at the end of a month even if laid by on a shelf and let alone. For most purposes I am a firm believer in the slip system for note taking, but not in the laboratory. Here every record should be a permanent one and its elimination from the book should be made as difficult as possible. In choosing a style for our note-book we cannot do better than to follow pretty closely the standard form of field note-book of the civil engineer with its handy size, its substantial paper, its leather cover and its rounded corners, all of which points, though trivial, tend mightily toward neatness. Of course for most laboratory work the ruling of this book is not suitable and a simple cross ruling may well take its place, with perhaps every fifth line a different color. I had the honor of describing a book of this sort to the Society some years ago, which I understand has since then been adopted in several laboratories outside of our own institution, where its use is quite general. The cost of such a book as this, while not enough to be a burden to the student, is sufficient to give him a property interest, as it were, in its good condition. A very great help toward both carefulness and neatness is the fountain pen, which eliminates the smudge and makes it necessary to put down the right thing the first time. Another help is the slide-rule, which, apart from the other great advantage incident to its use, makes calculations in the note-book unnecessary, or if the slide-rule is not available even a small logarithm table is much better than nothing. One of the most difficult points to impress upon a beginner in the engineering laboratory is the necessity for noting all the details of his test however seemingly unimportant. This is much easier to accomplish where the student is not expecting to copy his notes. The need for a special training in this matter of the note-book finds no better evidence than in the very difficulty which is generally experienced in getting students to regularly and conscientiously make use of such note-book for their original notes. This disinclination to use the note-book which he must exhibit to his instructor, for the hurried insertion of more or less rough notes and results, which may have to be discarded, is indeed a very natural one and to overcome this, as well as to give the student correct ideas with regard to the use of his note-book, he should be taught that it is for his private use, and that while it should always be in such shape that it can if necessary be produced in evidence, it is not primarily for public inspection and that when the instructor examines it he examines it as a private record, and not in any way as a report on the work. In order to further carry out this idea, it is well to have the student make reports upon all or a part of his work, as based upon the results recorded in his note-book, even going so far as to address the report as he would to a client. For their reports, blanks may well be used to some extent, but I believe there is such a thing as going too far in the use of separate and detailed blanks for every kind of test. It does not give the student quite brain work enough in laying out and planning his notes. That some special detailed blanks are very desirable for the purpose of familiarizing the student with such methods of recording tests is not to be questioned, but for the majority of his work, I believe that the student should be given quite a general form of blank and obliged to fill in his own headings.

DISCUSSION.

PROFESSOR SMITH.—Professor Smith said that he had used, for several years, a combination of note-book, report slips and final reports. His practice, he explained, had been to have the student obtain a suitable book in which to record all the data which he obtains in the laboratory and also any notes he may make during his experiments. As much of these data as is considered necessary is copied into his final report which is made after each experiment is completed upon special paper and forms. The original note-book is handed in, on request, for examination.

Professor Smith further explained that at the present time at Pratt Institute he was using as an additional check, a little slip on which the student before leaving the laboratory hands in the memoranda of the principal observations he takes. The only use that is made of this check is, largely, to prevent the student from "doctoring" his data. Professor Smith said this system had been quite successful in his practice.

PROFESSOR EMORY.—Professor Emory said, with regard to copying notes into the note-book, he thought the effect of requiring a student to put a fact into his note-book as a final presentation of any matter will cause him, in a few months, to be so much more careful that the additional training will be worth the appearance of the book. Professor Emory said, further, that there is, perhaps, no subject in which the engineer needs training more than in English, and the requirement of a good, neat note-book from the first draft is a training in itself.

PROFESSOR SPANGLER.—Professor Spangler said that, for a good many years, he had had occasion to file his notes so that he could get at them. He had found that his experience would repeat itself every four or five years, and that it was often very desirable that he should be able to put his hands on notes that were old, and, therefore, he had found it very satisfactory to have all the matter relating to any one case or subject in one place. He explained that he might have half a dozen things on hand at the same time, and finds it convenient to use note-books which have removable pages. He will work on a case for a day, perhaps, then drop it for a month, and, in the mean-time, have other matters coming up, and this case goes along in the note-book with removable pages, without much attention being given as to where the details are put. When he gets done with a case all of the data for that particular thing are put in one place, and he has on his shelves the records of a good many cases, running for a number of years, and he can turn to them in a minute and get all the information he has in notes relating to these things. Professor Spangler, continuing, said that in his experience he had found, in the laboratory and in experimental work, in many cases that if a handful of notes taken at the time of the test were dropped on the floor and were then picked up it would be impossible to tell to what they belonged, and it seemed to him that when a laboratory test was finished a nicely written out report on the basis of papers such as these was not worth the time taken in doing the work. He has required, therefore, for a number of years, that the original records taken by the students in the laboratory shall be a part of the final report as far as the department is concerned; that is, to the final report must be attached the original papers. The speaker cited the following experience: For the first three months the men were in the laboratory these original papers were carelessly kept; they failed in dates, or in showing what the men were trying to do, etc., and it was impossible to tell to what they referred. After three months it was found that a student could and would put down the things he was trying to do. The speaker found, personally, that it did not pay to keep work done in permanent note-books as he had found it very difficult to refer to data which he had not taken himself in this way. What he is seeking is results; and he requires his students to write out a report which is reasonably full, giving such peculiarities of apparatus, schemes applied, results attained, etc., as have been observed, and there is a definite form in which it is required that reports should be made. The result is two sets of papers pinned together, and the whole being turned in and making a complete document from the original records to the final result. Putting all of one thing in one place is the best method, therefore he had discarded the use of note-books *per se.* It surely is desirable to teach the student the value of properly keeping the original notes.

ALLEGED MISTAKES IN ENGINEERING EDUCATION AND THEIR REMEDY. WRITTEN DISCUSSION.

1. BY ARTHUR N. TALBOT,

Professor of Municipal and Sanitary Engineering, University of Illinois.

Professor Raymond in his paper read at the 1901 meeting charges two fundamental mistakes in engineering education—wasted time and specialization in undergraduate work. Waste of time is attributed to three sources: (1) Too much vacation; (2) class work instead of individual work; (3) the mixing of engineering subjects with preparatory and general culture subjects.

In the discussion of these criticisms, some points may be approved and others disapproved. What is new and radical may prove not advantageous or not applicable to present educational conditions, and what is pedagogically sound and practicably applicable may be found already to exist in our engineering schools. The remarks here made will apply to schools under the more usual conditions—those under special conditions may require separate treatment.

The assertion that vacation is waste time requires proof. The establishment of so important a proposition is deserving of careful and elaborate treatment. It is even possible that vacation serves an important function in the development and education of the young engineer. All books and school and instructors may not make up the best development for the youth. Surely it will be accepted that employment on engineering work during vacation gives engineering experience, develops engineering sense, enables the student better to comprehend his later instruction, and aids in his general development. And who will say that the working under direction upon tasks involving some responsibility, the contact with men and affairs, not alone in engineering work but in ordinary business affairs and in many ordinary employments, may not form an important part of the education of the young engineer, nor that it may not well be given in intervals between the college years? Of the sophomores and juniors in attendance at the College of Engineering of the University of Illinois the past year, more than one half are known to be engaged on engineering work in this summer vacation, making with those engaged in work other than engineering five sixths of the whole number and leaving only a few otherwise seeking strength or pleasure. It seems to the writer that the average student beyond the freshman year is greatly benefited by his vacation experience, and that the development gained, as well as the relief from study, is well worth the time expended. The younger student needs the relief from continuous study, and any extension of study time for him may not properly include much instruction in other than manual matters. However, aside from the educational uses of vacation, it may be questioned whether from a pedagogical point of view the extra six months of the three vacations is lost to the student. Whether possibly somewhat too much time is given to vacation, and whether parts of the vacation may well be devoted to directed field work is another question and one which is worthy of careful consideration.

Nor is it certain that "the college professors have too much vacation." Judged from the standpoint of what is for the best interest of the student himself, vacation results advantageously to engineering education. Engineering is a growing, a changing profession. The instructor must keep in touch with the busy world. Inspection of works, the charge and responsibility of engineering work, the contact with men and affairs away from school boys and books, the stirring away from the tendency to routine and ruts—the effect of all this must be seen on the character of the instruction given. This change is of especial value to the young instructor, and the opportunity to extend his professional experience results advantageously to pupil as well as instructor. The salary gained does not count in the argument, since if he spent more time in teaching, the school must pay him in order to retain his services. That vacations are utilized for such purposes is illustrated in a state university where of nineteen teachers in technical engineering subjects, of the rank of instructor and assistant professor, thirteen are spending the summer vacation on engineering work, and four are engaged in preparing instructional work for the coming year, and the remainder are taking a well-earned rest. The older instructor will generally find that when department business is finished and plans for the coming year are matured the leisure of his vacation has become reduced to a short period. It may be said too that the tension and hours of the work frequently carried by an engineering college professor will demand more than a business man's vacation, but of course this merely means that with only a business man's vacation the college professor must adjust his work to the business man's hours.

Professor Raymond makes the charge that not less than one half the time spent in the class-room is now wasted. This very grave charge should have the thoughtful attention of every member of the society. The remedy proposed is individualization of instruction. In this Professor Raymond includes both individual instruction as contrasted with class instruction and continuous work in a single subject at a time, or possibly in two subjects, until completed. Concerning this proposal, the following propositions are here submitted:

1. Individualization is already largely in use in engineering schools, particularly in specialized courses (to which Professor Raymond objects) and in laboratory courses. In engineering design, like bridge design, machine design, steam-engine design, architectural design, etc., the scheme which is in common use in the engineering schools with which the writer is familiar is similar to the proposal of Professor Raymond, except that the nominal period is three hours instead of eight hours. Likewise in subjects involving computations, investigation, special analysis, and individual responsibility, individualization is, it is believed, already largely the practice with our best technical schools. Thesis work may also be included.

2. In what may be termed fundamental or foundation subjects, individualization does not offer the best

method of instruction. The average student does not grasp the new and abstract concepts at first glance. His views and ideas are formed not only from textbook and instructor, but from the views expressed by fellow students—even their blunders and misapprehensions shown in the class-room are of educational value. Quiz and discussion are enlightening. Repetitions and re-affirmation are essential to fixing fundamental principles, and class-room exercises form the best means for doing such work efficiently, as well as the most economical method. This statement must not be taken to exclude the value and need of work with students individually, but such individual work ought to be subordinated to class work.

3. Individualization is not generally applicable to information subjects. Although matters included in the term information subjects are subordinate in engineering education, it will nevertheless not be denied that to a limited extent they form an essential and legitimate part of engineering education. Professor Raymond admits that lectures, explanations, class-room talks and the like should be given.

4. Certain exercises require party work. The discipline gained in carrying out the work of specified positions and of seeing the effect of carelessness or inefficiency in others is valuable. This method is applicable not only to such matters as railroad location and some laboratory tests, but also to many class-room exercises. To use a going athletic expression—it takes good team work to win, regardless of the individual skill of the players.

5. Continuous work in a single subject is in general

unpedagogical and uneconomical. The advanced student, or the student specializing along some lines, may profitably concentrate his work. Thesis work often may take a considerable part of a student's time. The subject of advanced engineering design is also of this nature. The nearer a subject approaches to specialized work the greater the proportion of time it may be permitted to take. But in general continuous work is opposed to established principles of pedagogy. Repetition, time for comprehension, return to the subject, "soaking in," clinching, all expressing psychological phenomena, are opposed to continuous treatment. A comparison of the attainments of a student in mechanical shop practice with those of an apprentice serving many times as many hours involves this difference. The ill result of cramming for examination illustrates it. The physiological statement that change is rest also has a bearing on this. Valuable as occasional concentration on a particular subject may be, the practice of giving all-day or even half-time treatment to all studies seems to the writer a very questionable procedure, and the objections are strongest in the fundamental subjects.

The writer does not wish to be understood as decrying individual instruction. On the other hand he believes that many instructors use this too little—that mere talking is not teaching, that to most pupils hearing a statement or principle makes little impression, that individuality must be recognized or principles will appear mere abstract generalities. The poor teacher may waste half the class-room time. The good one will adopt enough individual instruction to keep students in line.

The segregation of engineering subjects to an extent farther than now practiced in many of our best engineering schools, using the term to mean the exclusion of subjects not of an engineering nature, seems not applicable to the conditions of most of those schools. As an example, the state universities of the Middle West receive nearly all their students from the public high schools. The requirements for admission in the best of these engineering schools include the bulk of what may be taken by the high school pupil in four years. These secondary schools are for general education; they are not fitting schools for engineering colleges. The teaching of calculus may not properly be asked of them, and it is even questionable whether plane trigonometry may well be included in their curricula. Even with the three years of English and English literature required of the high schools, the requirement of exercises in English at intervals through the engineering course is quite important, and it is possible that further work in foreign languages may be advantageous. Beyond the above mentioned subjects, very little not of an engineering nature is now included in the engineering courses, and the introduction of some culture subjects is held by many engineering educators to be desirable.

The subject of generalization vs. specialization of the engineering course is difficult to discuss, since the point of view is so different and terms may not mean the same to two persons. As the writer views the course outlined by Professor Raymond, it is a good general course in civil engineering, containing a little more of mechanical engineering subjects than is common in civil engineering courses, but he can not see how so much time can be spent in some of these subjects unless these subjects are considerably specialized. Most civil engineering courses contain work in steam engineering, electrical transmission of power, etc., and most mechanical engineering courses include some surveying, cement and masonry, etc. Without wishing to prolong the discussion, the writer desires to express his opinion that some specialization is desirable, and that for example the civil engineer may well make his application of the principles of structural work in the design of bridges and the mechanical engineer in the design of machinery. Whatever may be said of over-specialization, it will be agreed that, important as general training and foundation principles are, engineering education is not complete without some training in details, some knowledge of methods of practice, and application of principles to minor matters, and some training in observation along a special direction. Specialized subjects permit such instruction. Without it the student may not appreciate many problems, discussions and principles given in fundamental subjects. Without it he may attempt to carry theoretical considerations into minor matters and attain an impracticable and inconsistent attitude. Some of the objections of business men twenty years ago to the engineering graduate may be attributed to such defects. It is not even necessary that this specialization shall belong the line of his later professional career; the training, the attitude of mind is the important part.

The time occupied in the proposed course does not differ materially from that of the conventional one. The usual course is at least 36 weeks in addition to holidays, and 5½ days per week may be counted. This makes Professor Raymond's two years equivalent to about 2⅔ years. The subjects of mathematics, English, etc., usually included in the course would require 1¼ to 1½ conventional years. Calling this 1⅓ years, the total makes 4 years. So far as the writer can judge, the general course would not vary far from the equivalent of that covered in the usual course. There would then be little difference in the total time put into the school work. It should be borne in mind that three vacation periods, not four, occur in the college course.

It is the writer's opinion then—for conclusions on this subject must be largely a matter of judgment—that vacations are educationally of value to the engineering student; that individualization may not properly supplant class work except in some specialized courses; that segregation of engineering studies has been carried as far as school conditions will generally allow; and that, essential as is the training in general principles, the giving of some specialized subjects is necessary to a well-rounded training.

2. BY CARL LEO MEES,

President of Rose Polytechnic Institute.

I have been requested to present a discussion upon Professor Raymond's paper, with special reference to the suggestions he makes therein as to the faults of our present methods in engineering education. The remainder of the suggestions in reference to requirements for graduation are to be left to a committee for discussion. I shall accordingly confine myself as closely as possible to the three sources of dissipation to which Professor Raymond refers, and the discussion will necessarily be categorical.

The first contention is that there is too much vacation, that vacation should be shortened both for teacher and student. That a considerable amount of time is or may be wasted in the ordinary school year is conceded, but whether the continuous session advocated in the paper will cure such wastefulness is questionable. The average age of students in our engineering schools at present is such that continuous application on one subject or topic is likely to make the student stale. Living continuously in an atmosphere of unchangeable character is not calculated to bring out the best efforts, either mental or physical. One is very likely to fall into a rut running along at a slow pace with little attempt at mental effort or nervous activity: change in conditions and surroundings stimulates and freshens both mentally and physically.

This does not mean that the vacation should be a period of idleness, but it should be one where the work is of such different character that the mind is thoroughly diverted, and the circumstances under which work is done are different. A large proportion of our engineering students do not do field, office and shop work in the direction of their professional studies during vacations. They are brought into contact and active competition with experienced men, learn to appreciate deficiencies in their own efforts and gather valuable information of great use in their future study. Engaged in this way they are impressed more deeply with the value and importance of time in a practical manner than is possible in school work. Such a change may be called a vacation in the sense that it is an intermission of the routine work and still offers diversion. So much in favor of a long intermission in school work.

My own experience is that short periods of rest, in so far as the student is concerned, are of great value, restoring elasticity where too continued application produces fatigue. We find the same mental condition there which all engineers recognize in matter.

To the professor also the vacation is of value, not only personally, but in his relation to the student. Close confinement in the school room and to teaching, as suggested in the paper, would so occupy the instructor that, if conscientiously done, no time would be left for research and study on his part. He would be prevented from associating to any considerable extent with practicing engineers or from working continuously on practical engineering problems such as are profitable during vacation. He would soon come to a standstill professionally, and would fall behind in the appreciation of the advances made in practice which without personal experience can come to him only through the journals. Every instructor should spend a few weeks every year in the intimate association with practical men and, if possible, engage himself in the practice of his profession in the ordinary commercial manner. So much in answer to the statement that the college professor has too much vacation.

I use the term "vacation" here in the sense of respite from school work, and not of idleness. Do what you may, in teaching there must inevitably be a certain amount of grind and routine work if the teacher be conscientious, which is very depressing and harassing, and a change for the teacher seems to me to be essential.

The demand of vacation for the teacher need not, of course, mean one for the students, as sessions might be continuously carried on by substitution from the faculty.

I have, however, already pointed out some of the reasons why a vacation for the student is desirable. My own preference is the shortening of the so-called long recess to two months, and the provision of several shorter intermissions of a few days during the year—making the school year forty working weeks of five and a half days each, equivalent to about fifty-five hours per week of study, recitation, lecture, office, laboratory, field work, or whatever may be required in the pursuit of the course. In addition to this some requirement for vacation work, either in the nature of a report upon the work done or something in the nature of a thesis which may be carried on during the intermission and be reported upon at the reopening of the session.

The second suggestion is in reference to practical substitution of individual work for class and lecture work of all kinds. The qualification is made that "class work has its value and general directions and explanation, as well as points not covered by text-books, may be imparted by lectures and class-room talks, but these should be the exception, etc." I believe that some subjects are better taught in class and the class-room than to the individual student. Very often in the discussion of a subject before the class, questions asked by several students will suggest points of view which would not be suggested in discussing the subject with an individual. This is of the greatest advantage to both teacher and student. (I assume, of course, that each student in the class is there for the purpose of obtaining as much knowledge and information as possible, and therefore takes advantage of every explanation or suggestion which may be made either by instructor or fellow student.) Individual work means very small classes if it shall be thoroughly successful. Every teacher has experienced the difficulty in meeting the demands of the students in the way of answering questions in office and laboratory work. Much time may there be lost if one student engages the professor for a considerable time while others are demanding attention. This may not be a tenable objection from the fact that as many instructors can be provided as the occasion demands. Still, when you look at the practical side, it is a very serious question.

Special individual work in the class-room or office is most advantageous if it follow lectures or recitations to the entire class where the general subject has been discussed, and the office or laboratory time is used in the working out of problems which have been explained. I fancy that in most engineering schools a very large proportion of time is given to this kind of work. Whether it can be increased indefinitely, so that lecture and previous explanations can be dispensed with is questionable.

Class and lecture work does permit the pushing along of the better students, though the entire class may be working upon the same general subject. The better students can be given a greater number of and more difficult exercises illustrating, fixing and developing the principle under consideration. Exercise work and much of it is, in my judgment, the most profitable. I am thoroughly in favor of introducing more of such individual work as suggested by Professor Raymond, but do not believe it can in any way take the place of much of the lecture and recitation work.

As regards the third suggestion, the segregation of engineering studies, so-called, I agree with the author that in general the best results can thus be obtained, though there is a possibility of extremism there also. After all, in engineering studies you will find constant application for the so-called general studies, which should be taught in engineering schools, and it is in their application that they are best learned. If all the mathematics or dynamics, for instance, is absolved before the applied mechanics, graphics, etc., is begun, then much in these branches will have been forgotten when needed, though, of course, it can be easily refreshed. In general also students do not take kindly to the abstract studies, but enjoy constantly to apply knowledge which is obtained. Carrying on parallel such subjects as physics, dynamics, higher mathematics, etc., with the engineering branches in which these find constant application seems to me to offer advantages perhaps greater than a too perfect segregation.

The suggestion that only one, or at most two, subjects should be studied at the same time I think again is somewhat extreme, though I am certainly opposed to the studying of half a dozen subjects at the same time.

The too continued application to one narrow study is certain to cause fatigue in younger students. There is a limit in time devoted to and quantity attempted of any single subject, beyond which mental activity will not be at its best. A certain amount of change brings better results; a reasonable mixture of food stimulates the appetite and facilitates digestion, mentally and physically. In most cases three subjects can, I believe, be carried on profitably side by side.

I fully agree with the author when he hopes that the time is not far distant when baccalaureate degrees will be required for entrance to engineering schools, but I believe that the time is still distant when it will be possible to enforce this.

With regard to the fourth suggestion, the generalization of the engineering courses, the suggestions made under this head meet my full approval, though I think the tentative outline for undergraduate work is somewhat narrow. There is contained too much of the so-called civil engineering and too little of general engineering. I heartily agree with the author, as well as with many who have gone before him, that engineering, as such, demands a broad knowledge in fundamental topics and that specialization should come later either in the form of graduate work or may even be taken in practice if proper student habits have been acquired and the ground work has been broadly laid.

In conclusion, I will say that I consider the author's suggestions well worthy of serious consideration and that working in the directions he suggests will undoubtedly be useful and will lead to better work in many engineering schools. I am not, however, prepared to say that going to the extremes which he suggests will be profitable.

In conclusion of his discussion, President Mees said "that most engineers think, more and more, of the general education as a tool rather than anything else," he thought the other considerations in Professor Raymond's paper were well worthy of thought, although he was not prepared to say that he, himself, would go to the extreme as Professor Raymond suggests.

DISCUSSION.

PROFESSOR C. M. WOODWARD.—Professor Woodward said that now as last year he did not believe that Professor Raymond more than half believed what he had said in his paper, but that he succeeded in arousing a very interesting discussion. The speaker had but one or two things to say, and his first point was as to *periodicity;* Professor Raymond wishes the drill and training to go continuously. It seemed to the speaker that such a course is opposed to nature and to art. Professor Woodward told of a friend of his who went to live in the Sandwich Islands, where the thermometer never goes above 80°, or much below 70°. He thought that would be a splendid place for apple trees, because they could grow all the time. It was a fact, the trees grew and grew, but they were not very fruitful, and when he cut them down he found there was one continuous layer of wood, without any grain. The speaker thought these layers that are being put upon the student are absolutely essential to his healthy growth. In nature is the alternation of day and night. Professor Raymond might say that half our time was wasted in sleep. The speaker said he did not think that any of these natural changes were accidental, but that they are absolutely essential to our healthy growth; that when the Sabbath was instituted, whether through divine inspiration or not, it was a wonderfully wise thing that there should be a suspension of labor one day in seven, and he believed it is so in educational work. After a short respite we come back to the work with relish which would be impossible without. that suspension and absolute change. Therefore he was not in favor of fifty-two weeks of engineering in the year, or of fifty-two weeks of anything else.

Then, in regard to individual instruction, the speaker said that Mr. W. T. Harris, Commissioner of Education, had an argument in the advocacy of the public school over the private school, that in the class there was a certain leverage which a student utterly loses when alone. When all get together and try to work together, the subject is seen from the standpoints of a good many different people; and when a crowd of students get together in a corner and talk a problem over, that is one of the most profitable things they can do. They help each other through an exchange of experience. Therefore, there is an advantage of keeping them together on a common topic, with a common problem thrown at them. Let them help each other instead of encouraging them to flee from each other, in order that they may get suggestions and help by talking it over among themselves all they can.

With regard to general subjects, the speaker thought that culture should never cease, in or out of an engineering school. Every year there should be something going on to draw one away from the strict line of engineering to the consideration of matters of general import to the whole community. He believed such things to be very helpful. The speaker said that, in his institution, the students are given a little descriptive astronomy, so that they may not be ignorant of facts which everybody ought to know. Care should be taken that these things should not absorb too much time, but the programme should never be free from that sort of thing.

Professor Howe.—Professor Howe said that at the Case School descriptive geometry is an individual subject. He had never made any investigation as to the advantages of this method, but in talking, informally, from time to time with instructors and with students, he had found them united in saying that they thought the students did not get as much out of descriptive geometry as they would by class recitation. The speaker said that, in his opinion, if professors and students do nothing during the vacation there is a great deal of wasted time, but he thought it was true that a large proportion of the students work during the summer, and that work is of great value to them. He believed that on the part of the average student there is no demand for a shortening of the course, but there is such a demand from a certain class of students.

A great many men come to these institutions who are graduates, or who have been teaching, or in business, and who have finally concluded they wanted an engineering education—men from twenty-four to thirty-five years of age, and they one and all inquire if the course cannot be shortened. They seem to think that it ought to be possible for men of their age to get this course in less than four years. It had occurred to the speaker that in large institutions the course might be shortened for men who wish to have it shortened, by having a summer term, say of two months, for four summers. That would make eight weeks of summer vacation each year which the student could put in, in addition to the three regular years. If the work could be laid out properly the speaker saw no reason why the men who are strong enough to bear it could not take a technical course in three years.

Professor Johnson.—Professor Johnson thought it might be interesting to the audience to know what had been done at Harvard in the summer. The speaker said that they had been impressed with the desirability of generalizing the engineering course, and the last step that needed to be taken in order to make it possible to have the term work of the first two and a half or three years of the engineering course the same for the civil, mechanical and electrical engineers, was to put all of the work in surveying, railroading and geodesy and shop work into the summer. This step was accordingly taken. The student in civil engineering now spends eleven weeks of one of his summer vacations in camp at a distance from Cambridge, engaged in surveying, and finishes it all up there. That is all the instruction in surveying, railroading and geodesy that is given. The shop work is given in Cambridge, and prescribed for mechanical and electrical engineering students. These steps have, on the whole, proved very satisfactory. The speaker was under the impression that some of the other universities put more or less of surveying instruction into the summer. He thought it might be said that such work, off in the field in an attractive locality, was generally looked upon by students as a decidedly pleasant experience. In the case of his institution it throws together about one hundred students in pretty close relations, where pleasant associations are formed and good progress is made in the work.

PROFESSOR MCNAIR.—Professor McNair said he believed that a year ago he mentioned the fact that at the Michigan College of Mines a three years' course has been in existence for some time. There is a regular summer term, and the ordinary four years' course is compressed into three calendar years. There are six or seven different courses given during the summer term. All of the surveying is given, all of the shop work, and the course in field geology. The course in testing materials of engineering, and some others, are put into the summer. The students regularly work for a year of forty-five weeks; the longest vacation is four weeks, which comes in September. As short as this vacation is, during it a great many students find employment in the line of their future work. The Christmas recess is quite often taken up by the students in some special line of work.

PROFESSOR WILLISTON.—Professor Williston said that it seemed to him very strange that there should be so much difference of opinion, as appears to exist, as to the number of subjects which a student can most profitably carry at one time. It seemed to him that this is a subject which is capable of a more or less exact solution. This number would differ, of course, with the individual to some extent, and it would differ with the character of the subjects carried. The speaker said that we had in the catalogues of some of our institutions the expressed opinion of faculties of these institutions that as many as eleven or twelve subjects can profitably be carried at a time and Professor Raymond has advocated the concentration of the students' entire working time on a single subject. Professor Williston stated that he had had several years' experience as secretary of the faculty of engineering of the Ohio State University, where he arranged courses for a very large number of special students, and he had had in this way an excellent opportunity to judge of the effect of giving three, four or five subjects to different students at the same time, and that experience showed him that there was a definite number of subjects for the average student which he could most profitably carry at one time. That while this number varies with the individual and with the subject (as has been stated), this variation is comparatively slight, and he did not hesitate to say that with engineering work and students of undergraduate age, it is never less than three nor more than five subjects, or, at the utmost, six. It would only be unusual circumstances that would make it six, where subjects that are closely related, so that perhaps two or three of them would constitute, in reality, a single subject so far as thought is concerned. The speaker thought that if all were to try a little experimental investigation of this kind and observe the effects on the students of the different terms' work in which different numbers of subjects were carried, some valuable data would be collected and we would be prevented from having such a diversity of opinion as had been expressed, on so important a subject.

Professor Williston also said that a number of speakers had advocated placing all the shop work, the field work, etc., of the civil engineering courses and similar work, in the summer vacations, and that there seemed to be a growing tendency in that direction, crowding the more purely intellectual work into the regular eight or nine months of the course and putting the practical application of it into the summer vacation. He wished to register his opinion as directly opposed to such a policy. He did not believe it was sound educationally, and he believed it would be, in the long run, a bad thing for the student. Shop work and field work, and practical laboratory work, he thought, ought to be put regularly in the course to give a daily application of the principles which the students are learning. The application of some of these principles six months later will not take the place of the daily application of them at the time the student is studying them in class.

The speaker was cordially in favor of vacation practice wherever possible, to give the students opportunities for more extended work under conditions more closely resembling those of commercial work than was possible in term time; but he thought that this was no reason for reducing the amount of time devoted to the practical work during the regular term. He believed that the variety of work, going from class-room to laboratory and from class-room to shop and field gives the same kind of change, mental rest, and recreation that Professor Woodward spoke of in connection with the Sabbath Day, and that this kind of variety of occupation was absolutely necessary to the best mental development. It seemed also to him that there always ought to be a certain proportion of time given to the work of a purely intellectual kind, and a certain proportion to the practical application of the principles studied in class-room, in the field, shop or laboratory, and his experience had convinced him that this relation was a fairly definite one.

The speaker thought a study ought to be made of those conditions in order to find out just what is the most efficient proportion for these different kinds of work. He had found that two hours in class-room, followed by two hours in which the student is making a very direct application of the principles in some such work as designing, which is largely intellectual and creative work, and an equal amount of time in the more practical work where the student is putting into practice what he has learned or is trying experiments to prove some things which he has heard discussed in the class-room, gave most satisfactory results. He felt that any wide deviation from these proportions would be accompanied by a loss of efficiency.

Professor Williston gave these as his reasons for believing it to be unwise to crowd the practical work out of the regular course during term time into the summer vacations.

PROFESSOR CALDWELL.—Professor Caldwell wished to lay stress on one point that Professor Mees made, namely that of carrying the practical work along with the theoretical work in order to give the student more interest in his work. The speaker had no sympathy at all with that pedagogical theory of making all the work the student does intensely interesting, but he thought that by keeping the practical work along with the theoretical the student's interest in the theoretical work could be better maintained, and that he could thus be made to see why he should do things that are not entirely agreeable and pleasant.

PROFESSOR TYLER.—Professor Tyler said he had had frequent occasion to consider this matter of the number of studies which a student should attempt at any one time, and that in his opinion it is not so simple a problem as Professor Williston implies. In the first place it varies with the student's age; an older man can do better work in a smaller number of subjects. A student at an institution where specialization is facilitated by a wide range of work may have in a given term as many as ten distinct subjects. But the actual variety may be really no greater than if he had only five or six subjects. In electrical engineering, for example, students may have physics, theoretical electricity, physical measurements and physical laboratory at the same time. It would hardly be fair to count those as four distinct subjects. Again, a subject like free-hand drawing does not add proportionate strain on the student.

As to the reference which had been made to the possibility of shortening the course in a large institution for an older man, Professor Tyler said that he had continually met that pressure and recalled only one case in which he had attempted to shorten the course for a man. The man in that case was twenty-five years old and there was reason to believe he was of good intellectual caliber. He is likely to complete the course in civil engineering at the end of a three years' residence, but he is merely the exception that proves the rule.

The speaker wished to ask if President McNair's experience in Michigan is not also an exception; that is, whether he would consider the year of forty-five weeks applicable more generally, or only the local conditions which justified it.

President McNair.—Professor McNair said that there would undoubtedly be special conditions surrounding his institution which facilitate the application of their methods: that his former remarks were made rather to draw attention to the fact that the three years' course is possible under certain conditions. He did not wish to be understood as implying that this method could be applied everywhere, but that certainly something can be done in that direction. In Michigan, for example, there are cool summers in which the student can work his brain rather vigorously, and not suffer from it under the climatic conditions. There is a pressure in the work to shorten the course. Older men apply for instruction as a rule and the possibility of putting the course into three years certainly enables a man to complete it who could not otherwise do so. Professor McNair said in conclusion that he was talking only of the conditions at his institution.

Professor Flather.—Professor Flather said, referring to the general number of subjects that may be carried by a student at one time, while this is perhaps not susceptible of mathematical formulation, he believed it may be generalized to a certain extent so that we may tell what a given student can profitably carry. The speaker said that in his capacity as chairman of a committee which has to deal with the shaping of individual courses for students who are more or less irregular, conditioned students, and others who wish to take advanced work, he found a rule which works very well is to ascertain the number of points or actual hours which a student may carry during the term and this has been reduced to a mathematical formulation.

In the technical departments, as a general rule, the students carry from four to five subjects. The catalogue designation may give six or even seven or eight different titles in the list, but some of the subjects are more or less connected. In arranging a course for a student, if he have a short number of subjects, he can be given forty-five or fifty points per week. In determining these points a recitation or lecture subject which requires preparation, or the writing of notes outside, counts for two and one-half points for each class hour; that is one hour is always allowed for the college period and one and one-half hours for preparation. A laboratory, shop, or drawing period counts as many points as there are actual hours per week devoted to the subject. If these various points are made up of a relatively large number of subjects, it is found that the student cannot carry so many different subjects, and he is limited to about forty points, which may be increased somewhat with mature students.

The speaker said that, in his opinion, the question is susceptible of a certain amount of generalization which, of course, will vary, depending on the age of the student and his ability.

PROFESSOR TYLER.—Professor Tyler thought that Professor Flather's remarks referred to the question of weighting the subjects rather than to variety of work. At the Massachusetts Institute of Technology each subject of instruction is assigned a definite number of hours for exercises and preparation. This serves as a basis for standardizing the courses and, at the same time, measuring the work of a special student. The formal allotment for a regular student is forty-eight hours per week, including preparation, and a special student may take more or less according to his capacity.

PROFESSOR FLATHER.—Professor Flather said that regarding summer work, possibly field work with the kindred class-room subjects, may better be taught during the regular college year, and he was of the opinion that laboratory work can be better taught then than if it were by itself in the summer; regarding the shop work, he felt satisfied that it would be time well spent to devote a portion of the summer to shop instruction, taking it out of the regular college hours—the regular forty weeks—and putting it into a period by itself, for if the question is studied closely it will be found that shop studies will have very little relation to the subject of mathematics, physics, descriptive geometry and other subjects taught during the first two years of the course. It is true that lectures are given in forging and in pattern-making and foundry practice, and sometimes books are used; but the speaker thought that taking these subjects, with the class-room work which goes with them, and putting them into the summer time, will strengthen the course. As regards the other subjects, the speaker was not so sure but that they should be retained during the regular time of the year.

PROFESSOR WOOD.—Professor Wood asked if there was any mechanical or electrical engineering course in which but one engineering subject was taken up, for the time being, to the exclusion of all others. While the merits of the method had been set forth for certain civil engineering courses, it appears to be untried to any considerable extent in other branches. During the past few months the matter had been considered somewhat by the speaker while reorganizing courses in mechanical and electrical engineering where he is now teaching. Two objections had been raised to the "single subject" method: First, defective preliminary training makes it necessary in many cases to overcrowd the student during the four years; as a result, there is difficulty in arranging the time with other departments. Second, by this method, we lose entirely the direct and indirect aid from the study of other subjects closely related to each other, and all together aiming to give a broad, accurate and working knowledge of the subject at hand. To these might be urged the less serious objection that the system tends strongly to weary the student and he loses the ability to turn from one subject to another when necessary and attack a new problem with energy.

Professor Wood referred to questions in a recent examination given to a freshman class in shop work, which required for satisfactory solution some knowledge of elementary geometry, algebra and simple engineering design. It was evident that a study of the applied work brought out, or better rounded out, the class-room studies. It is much the same, only to a greater degree often, in advanced work in mechanical and electrical subjects. The speaker might have favored the plan as a whole, did it not tend to defeat the more evident and important results obtained in a four years' course as carried out under the more common methods now in vogue.

Professor J. P. Jackson.—Professor Jackson said that the engineering faculty of The Pennsylvania State College carefully considered the question of summer work and decided that it was advisable to have a summer school of two weeks' duration immediately after commencement. The board of trustees approved of the plan, and as a result the summer term has now been in operation for a number of years. The reason for establishing a summer term was two-fold: Rapid growth of the college made it impossible to schedule all the laboratory, draughting and shop work in the time available during the regular college year; and in the second place it was considered quite important that at least a small portion of the "practical" work be given during consecutive periods of a day each.

It has been the endeavor, in the institution named, to teach the laboratory, draughting room, and shop work concurrently with the class-room work so that the student may have the opportunity of proving the principles learned in the class-room by actual experimentation. The speaker believed that this policy would be maintained in connection with the work of the regular college year. But the additional one hundred hours of practical summer work—draughting, surveying, laboratory, etc.—has proven to be a great success. The students themselves firmly believe that they obtained much good during the two weeks. The speaker said he should be very sorry indeed to see the whole vacation given over to college work. The average earnest student is certainly benefited by a substantial summer vacation, as is attested by the need of the professors themselves for a change of work, a rest, or possibly a change of climate. But for short periods, a month or less, he thought the scheme he had suggested quite advisable, as it gives a taste of actual shop practice which cannot be obtained by work during the ordinary nine months' term.

PROFESSOR FRENCH.—Professor French said that at the Worcester Polytechnic Institute he had had a little experience with the summer practice in civil engineering under such conditions that he had come to the conclusion that all the field practice cannot well be separated, in civil engineering, at least, from the routine class-room work. In his course in civil engineering in each of the three summer vacations, three solid weeks of ten hours a day were given to field practice, which is conscientiously put in. In one of those subjects it happened that there was no time to do any of the instrument work until the summer practice, and he thought this was a mistake, which has now been remedied by giving at least one exercise per week in the field, concurrent with the text-book work. However, he believed that if it were necessary to do away with either, he would hold the vacation practice, at least in surveying; that the organization of a party which can stay in the field a continuous time is a good thing. Thus, in his case, part of the work in the field is done during the term, and then three solid weeks in the field during vacation, on a practical basis.

PROFESSOR JOHNSON.—Professor Johnson said that the practice at Harvard is to give all the surveying work in the summer, lectures and field work together, so the work goes right on with the most intimate relation between the practical and theoretical side. So far as the demand on the instructor is concerned, the instructor does not do any other work for the university in the year. He is on leave of absence in professional practice the rest of the time. The instruction in shop work is given in Cambridge by a member of the instruction corps who devotes a very small amount of time to instruction during the college year, and his other duties are such that he must be in Cambridge in the summer in any event. The result is that in neither case is the work excessively burdensome to the instructors.

PROFESSOR WALDO.—Professor Waldo said he supposed soon Professor Raymond would be heard from, but before he spoke Professor Waldo wished to go on record as standing with him in one particular to a certain extent, that is, that the instruction, no matter how large the classes, must be individual. The speaker said that this is true in a very important way, for the instructor must know the men who are reciting to him. First of all the instructors must get acquainted with the scholars individually; secondly, they must, by some psychological process, discover the attitude of the individual towards the subject, knowledge of which the instructor is trying to impart; third, he must devise methods to meet the difficulties which the student encounters, and finally he must pass judgment upon the student's knowledge of the subject, and either allow him to proceed to others on which that work depends, or oblige him to go over the work again; so that, in a very important sense, the fact must be recognized that the instruction must be individual, but at the same time there is the class work which is exceedingly important. The speaker said it had been his experience before classes of twenty-five or thirty that the interest of the class has been so awakened that when some question is asked there is a united effort on the part of the whole class to get at the solution of it, and one feels a sort of electric thrill as everybody is at work at the same thing; and no matter how difficult the problem may be it rarely happens that this combined attack is not successful. It is a kind of unification of minds upon one thing, and there comes out of it a mighty stimulus, so that when such team work is done the speaker believed that the student comes to a correct sense of his own powers and is helped to stand alone. The joy of strength and freedom gets hold of him, through which he becomes a sort of automobile, and that is what is desired, to make automobiles of our students.

Professor Raymond.—"I will not detain you long in closing. I only want to say that this thing is coming. It is in the air. If you read between the lines, it is in the daily press; it is in the educational journals; it is in the presidential address which we heard this morning; it is in every defence of present methods which we have heard this afternoon. It is coming. There are a few minor points which I would like to take up. President Mees assumes two different conditions, as suits his convenience; the first, that all of his students are working because they were sent to school; and, second, that they are all working to receive the utmost advantage.

"Then again, there is one statement made by Professor Howe, that descriptive geometry is, with him, an individual subject, and the result is not so good. When I studied descriptive geometry it was an individual subject because I was the only student in the class. Afterwards I attended Washington University and took up stereotomy, and I remember coming to one particular problem which was given to the class by an excellent instructor, Dr. Engler. We boys were separated in different rooms; I was the only civil engineering student and worked in a room by myself, and I remember Dr. Engler came around to me to know if I could do that problem. I said I thought so, and he told me he thought I could not; that none of the rest of the class could. But I solved the problem. I had had individual instruction, and the class had had class instruction. This may have been only the exception that proves the rule.

"In all that has been said, so far as I can see, the difference is one of degrees. There is simply a difference of opinion as to how much contact with men is necessary for a scholastic degree; as to how much individual work is good for the student and how much class-room work. I believe in individual work, in vacation, and I believe in class work and in continuous work, but I believe in more individual work and more continuous work than you do.

"I feel much honored that you have given this subject so much attention, and the fact that you have given so much time to it, together with the evident tendency in my direction makes me begin to feel like a 'Voice of one crying in the wilderness.' "

THE REPORT OF THE COMMITTEE ON TECHNICAL BOOKS FOR PUBLIC LIBRARIES, JUNE 18, 1902.

BY C. F. BURGESS, CHAIRMAN.*

The task which was undertaken by your Committee on Technical Books, appointed at the last meeting, is such a considerable one that it has been impossible for the members to complete it and make a formal report at this meeting.

The demand for the results of the work which the committee has undertaken has been shown to be very great and the successful completion of it will undoubtedly be to the advantage of engineering education as well as to public libraries.

A paper presented at the annual meeting of the American Library Association at Boston during the present month, dealing with the choice of technical books, brought forth many comments which showed that the librarians are in need of just such aid as it is the purpose of our committee to give.

A large number of libraries both large and small, notably among the former being the Model Library at Providence, R. I., have been visited and their technical departments studied. A number of libraries are devoting very considerable attention to this line of work and are making progress in improving their technical departments in spite of the difficulty of evaluating the technical literature.

It is expected that the committee will be able to make a definite report at the next meeting.

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* The names of the remaining members of the Committee appear on page v of this volume.

COURSES OF INSTRUCTION IN IRRIGATION ENGINEERING.

BY ELWOOD MEAD,

Professor of the Institutions and Practice of Irrigation, University of California; Chief of Irrigation Investigations in the United States Department of Agriculture, Washington, D. C.

The most important industrial problem of the western half of the United States is the distribution and control of water used in irrigation. Although in its infancy, irrigation has reclaimed from aridity an area larger than the State of Maryland, transforming it from land barren and practically worthless to the most productive farming lands in this country. It has been a large factor in building up cities like Denver, Salt Lake and Los Angeles, and furnishes employment and support to millions of people. These irrigated areas are scattered over an area larger than any European country, save Russia. The waters of great rivers, like the Snake and Missouri, have to be divided among thousands of ditches, which reach for hundreds of miles from the mountains out on the plains. The problems created by this development are certain to grow in complexity and importance with the coming years, and their solution involves a knowledge of many subjects not dealt with in the ordinary course in civil engineering. It is in every way desirable that this omission shall be supplied. In no other field of engineering is there greater need of trained intelligence. The present leaders have all been educated in the school of experience, but this has often proved a costly one for their employers, as well as exceedingly disagreeable to the engineer. We have now had sufficient experience and enough information is available to provide a systematic course of instruction in this branch of engineering. If the colleges will arrange this and present it in orderly form, they will render the country and their graduates a service of great value. It will enable young graduates who wish to follow irrigation engineering to begin with a fund of practical information which it might otherwise take them years to acquire, and will assist in the solution of social and legal problems which need the calm and dispassionate inquiry, and disinterested consideration that schools are admirably fitted to give. It will not be necessary for this paper to discuss the course of instruction where it does not differ from that of the usual course in civil engineering, further than to say that special training in irrigation engineering should not begin earlier than the junior year. For the freshman and sophomore years, the usual course of instruction in civil engineering is precisely what is needed. The departure from the usual course in civil engineering is illustrated in the course of study in irrigation engineering of the University of California, which is given at the close of this paper.

The special training should begin with instruction in the work which the beginner in irrigation engineering is first called to do, and which will include the survey and construction of irrigation canals, preparation of plans for reservoir dams, or for pumping plants to lift water from streams and wells. The instruction in the location of irrigation canals and examination of reservoir sites, should give special prominence to certain subjects which have little or no consideration in other branches of engineering work. The list which follows is not intended to be a complete enumeration, but to indicate the character of the information with which the young engineer needs to be provided.

In the location of an irrigation canal, the young engineer needs to have some knowledge of the behavior of different soils when subjected to the action of water. There are certain soils that leak water like a sieve, and there are others that are almost impervious. The engineer must be able to estimate beforehand what will be the approximate loss from seepage and evaporation before he can intelligently design the carrying capacity of the different sections of his proposed waterway. It is necessary that he should keep in mind the danger which attends canal building through gypsum and alkaline soils. Immense sums of money have been lost through the location of works by engineers who did not recognize what, in western parlance, is called "bad-land" soil, and who had no conception of its treacherous character. The breakage of canals built through soils which, when touched with water, dissolve almost as readily as sugar, or through soils that lose more than half their water supply by seepage, has proven the cause of disappointment to their owners, and oftentimes of ruinous losses to the settlers who depended upon them.

In order to estimate intelligently whether there is water enough to irrigate any particular area of land, the engineer needs to have a thorough understanding of the duty of water. He must know how much water it takes to grow a crop, and the variation in requirements of different crops. It is not enough that he should know the volume of water consumed in a year, but he must also know what will be the month of greatest need, and how much water the canal will be required to carry to supply this. The usefulness of a canal depends largely upon its ability to meet emergency needs, just as the value of a stream for power purposes depends upon its low water flow. It will not answer to be able to flood fields in September if the canal could not supply the amount of water needed in August. The crops ruined by drouth in the earlier month cannot be restored by irrigation in the later one.

The measurement of water is one of the important questions with which the irrigation engineer has to deal, and he has to deal with it under very primitive and often unsatisfactory conditions. The location of the lands to be irrigated frequently requires that the gates which turn it from the main channel to the different farms should be of different sizes, and located under different conditions regarding grades and pressures. This renders it difficult to adjust the forms and sizes of measuring boxes, so that they can be relied upon to deliver the required volume. In doing this, the irrigation engineer has also to understand that he is not dealing with water alone, but with human nature, and this becomes especially conspicuous in the arrangements for the distribution to farms from the main canal. Important enterprises have often failed because the unit of measurement was one which the farmers did not understand, or against which they had a prejudice. The farmers of some sections insist upon having water measured by the inch; others will have nothing to do with this unit and insist upon a different one, and where their prejudices are not met they settle under other canals.

The irrigation engineer has an especial responsibility as a business adviser of his clients. The construction and operation of canals as carriers of water is a new form of business enterprise in this country. Capitalists know little about the conditions which promise success and those which foreshadow failure. Oftentimes these works are located in remote localities, which can only be visited at a large outlay of time and great personal discomfort. Investors, therefore, rely largely on the opinions of engineers regarding the merits of these projects. This renders it necessary that the latter should be well informed regarding the business history of irrigation development, and know all the underlying influences which help to shape final results.

The laws and customs which govern the ownership and control of streams have as much to do with the success of irrigation properties as the character and amount of the water supply. The engineer, who is acting as a business adviser, must understand the significance of these laws, know the character of ownership in water which is recognized, and the amount of the supply which is already controlled by existing rights. He must advise regarding the framing of water contracts, and to do this must know what stipulations have worked well in practice and what ones have been a source of litigation or discord.

The settlement of the arid region is already creating important problems in statesmanship and economics. Within that region homes are to be made for millions of people. The prosperity, if not the very existence of the homes created, will be conditioned on the ability to use water in irrigation. To secure this, laws must be enacted which will provide for the establishment of just and stable titles to water, and for the protection of these rights in times of scarcity. The regulation of rivers which this requires involves not only the adjustment of hostile and conflicting interests of individuals and communities, but even of different States. The interests are so important and the domain to be dealt with so vast that the single irrigator is helpless. Only public control and administrative ability of high order will meet the needs of the future. The information upon which both laws and administrative practices must be based must be largely gathered by the engineer. One of the most urgent needs of the present is expert study of the agricultural and engineering questions involved. We need to know where water is being used, where it can be used to the best advantage, to know what are the character and extent of vested rights, and to have a better understanding of the respective spheres of State and National authority.

The engineers who are to deal with these questions should come to their work with all of the training which the schools can give. To meet all these varied needs courses in irrigation engineering should embrace three different lines of instruction.

1. Practical irrigation engineering including problems of location, construction and operation of canals, and the construction and operation of reservoirs and pumping plants.
2. Business problems connected with the disposal and distribution of water among irrigators.
3. The social and legal problems connected with the ownership and administration of streams used in irrigation.

A number of engineering schools are already giving a more or less complete course of training in this subject. The pioneer in this work was the State Agricultural College of Colorado. The University of California is the latest, and the course of study adopted in that University represents the views of a number of instructors practically familiar with the conditions of the arid region.

UNIVERSITY OF CALIFORNIA—COLLEGE OF CIVIL ENGINEERING.

Irrigation Engineering Course.

Freshman Year.

	1st Half year. (Units.)	2d Half year. (Units.)
Mathematics—(3A) Elements of analysis, with applications	5	5
Physics—(1) Elementary course; lectures and laboratory	3	3
Chemistry—(1) (2) Inorganic: lectures	3	3
(3) Laboratory experiments and (4) Qualitative analysis	2	2
Drawing—(1) Instrumental and (2A) descriptive geometry	2	2
Military Science—(1) Two exercises each week	½	½
Physical Culture—Three exercises each week	..	..
Totals	15½	15½

Sophomore Year.

Mathematics—(3B) Elements of analysis, with applications	3	3
(10) Problems in the calculus	..	2
Drawing—(2B) Descriptive course	2	..
Physics—(2A) General course	3	3
(3) Laboratory	2	2
Surveying—(1A) Lectures	2	2
(1B) Field practice and mapping	1	1
(1C) Topography	..	1
Elective—	2	1
Military Science—(1) Two exercises each week	½	½
Physical Culture—Three exercises each week	..	..
Total	15½	15½

Junior Year.

Irrigation Engineering—	3	3
Civil Engineering—(8A) Strength of materials	..	4
Materials of construction	2	..
Physics—(5) Analytic mechanics	4	4
Agriculture—(1A) (1B)	3	3
Drawing—(5)—Graphostatics	2	..
Elective	1	1
Military Science—(1) Two exercises each week	½	½
Totals	15½	15½

Senior Year.

Irrigation Engineering—Institution and laws	3	..
Civil Engineering—(13) Foundations	..	2
(7A) Frame structures	..	3
(12) Construction of dams	3	..
Mechanical Engineering—(2) Hydrodynamics	3	..
Agriculture—(4A) (4B) and Horticulture, general course	3	3
Elective	3	7
Thesis	..	..
Military Science (1)	1	1
Totals	16	16

DISCUSSION.

PROFESSOR MEAD.—There is something more than one third of this country where agriculture and, in a very large measure, industrial life is dependent on irrigated agriculture, and it is impossible for people to live there cheaply enough, or have comfort, without the artificial application of water. There is also a very large field in which irrigation is certain to be employed in the humid portion of this country. There has been more money spent in pumping plants in Louisiana than in any other of the arid States in past years, and the conditions are such all along the Gulf Coast that there is certain to be a large resort to irrigation in agriculture. The growth of irrigation creates certain questions that ought to be solved by the engineers and which have been too largely neglected by them thus far. These questions are not questions of construction, but they are legal, social questions requiring engineering knowledge in their solution; questions with which the engineer is better able to deal than any other kind of citizen. In this western two fifths of our country we have thus far made one fundamental mistake: We deal with irrigation as a private matter. People living along a river have built ditches, but the community and State generally have looked upon that as a matter of individual enterprise. If a man wanted to build a ditch that is his own affair. If an eastern syndicate built an irrigation canal through ten thousand, or fifty thousand, acres, the difficulties were their own affair; it was not the concern of the community or the State. So we have had in the West a tremendous development just treated as an individual matter. That did very well at the outset. So long as there was more than enough water to fill the ditches it did not make any difference as to titles to the water or what sort of an arrangement the different enterprises made. But the very moment that you have more canals along the river than it can fill, the whole situation changes. It becomes then of the utmost importance to know which one of those canals is going to run dry.

Without some regulation, the one nearest the mountain takes all it wants and the one farthest down goes dry, and then there are controversies over the control of the commodity on which all prosperity rests, which become all the more severe and dangerous and costly with the extension of development. Every new farm brought under cultivation increases the gravity of the issues presented.

There is this further issue raised: All this work being done by private enterprise is based on absolute ownership of the water. It is only a step from the assumption of absolute ownership of the water to the effort to secure legal title to the stream, and in the West there has arisen the doctrine of private ownership of streams. This doctrine has already found its sanction in legislation and has been recognized by the courts. Then comes the spectacle of men assuming a right to the range of the snows of the mountains, and they sell or rent what they do not want to use.

These are all questions that are beginning to press for immediate solution, and the importance of an adequate engineering understanding of them comes in this form: The greater part of the money that has gone into engineering enterprises has come from the East; so the people interested in development, the people of the East who were looking for profitable investments, have made tremendous expenditures of money in irrigation work, and they have depended entirely on engineering advice regarding prospective profits and successes. So the engineer has become the counselor not only in the practical obstacles and questions of construction, but in regard to the operation of law and in regard to the revenues to be derived. Now in order to be a safe adviser it is necessary that the engineer should understand local conditions; more than that, he needs to understand the customs, laws and decisions of the courts of the country. There is nothing so seductive as an irrigation proposition if you do not take into account that the whole industry is in an unorganized state, and thus there have been gross misconceptions as to the extent of the question. There has, therefore, been continued litigation over water rights and water rates, so that the blame, indirectly, for the unsatisfactory conditions prevailing in the West and the losses encountered in the West comes back, largely and ultimately, to the lack of knowledge of the engineer. We want to train up men who will be equipped to deal with these questions, and we want to train men who will be effective administrators. This is going to be a great field for the employment of engineers. The owners of works are beginning to realize this fact. In the first place, where large canals were to be built, there was usually somebody, a protegee of the man who furnished the money, without a practical knowledge of engineering. He was put in as administrator, and it was a costly experiment. The handling of the large works is going into the hands of the civil engineers, who are the men who can distribute the water-supply accurately and justly. The extent of the country involved and the issues involved make it a matter of public importance that engineering schools should take this matter up and deal with it, especially the schools in the West where it has a vital relation to the future advance and prosperity of the country.

In the last two years of a four years' course it is necessary to deal with these features of irrigation engineering that make it a distinctive profession. There is need of the schools, of men who have the opportunity of taking up under a teacher the study of the fundamental issues involved in determining what sort of ownership ought to be recognized in running water; what sort of administration and legislation should be devised for the distribution of a river or system of rivers. The diverse and conflicting interests of communities and even of different states should be justly settled by legislation so that the farmer shall be as secure one hundred miles away from the source of the stream as is the man who lives right at the foot of the mountain. The sooner that matter is taken up and dealt with the sooner the irrigation system of the West will be what it ought to be.

PROFESSOR NAGLE.—Professor Nagle agreed with the speaker in his statement as to the necessity for some such system of educational work, especially in the West and Southwest, and possibly in the more humid regions; and just as an instance of the lack of application of engineering knowledge, Professor Nagle mentioned the case of a series of experiments which he made last year on a river. Plans had been projected there for building canals intended to water about 100,000 acres of land; his measurements, however, showed that there was only water enough for less than half the projected acreage. There seemed to have been no idea of measurement, beforehand, to determine the amount of water available. Nothing, practically, was known about figuring water in that kind of work, and it seemed to Professor Nagle that there was urgent need for some system of education in irrigation matters.

PROFESSOR C. M. WOODWARD.—Professor Woodward said he supposed a man owns what water falls on his roof, and that if he digs a well he owns what he gets out of that. Now if a man owns fifty square miles of land, including the sources of a stream, he would like to know if that man owns the stream.

PROFESSOR MEAD.—Professor Mead said it would depend on what State the man lived in; where the land was; that in nearly all the Western States there has been established what is locally known as the doctrine of appropriation. In theory that means that whoever has beneficially applied the water of a stream first is entitled to control and protect it forever. This is the doctrine of appropriation and priority. Where the water came from had nothing to do with the question of ownership and control. If a spring rises and falls down into a stream and the stream is appropriated before the spring has been acquired, the proprietors can compel the owners of the land surrounding that spring to let it run forever. It belongs to the people who appropriated the stream. At first the doctrine had sensible limitations, and there is no objection to it if it is really restricted to beneficial use. But in time claims were filed, and a man found it just as easy to put in a large claim as a small one, and there was no official determination of what was being done. Public sentiment greatly changed and the actual use of water began to be regarded as less important, and the declaration in the recorded statement began to be the important thing. There was no administrative control, no examination as to how these rights were to be established. Everything was left to the courts, and men who went to have their rights legally determined would oftentimes agree among themselves as to how much each man should claim, and they would go into court and institute proceedings to have their rights judicially determined. The proceedings were held miles away from the stream. There would be no adverse testimony, and the only evidence before the court was that of the party seeking to acquire control of the property, and they would oftentimes get rights to a hundred times what could be deflected from the stream. In a number of States an adjudication of that kind becomes a vested right after a few years, and then the man is the owner of it. Now the injustice of this is that he dictates the terms. It is not a question of ownership of the land, but certain greedy people have complied with certain legal formalities that determined the ownership.

Now, some standard for the use of water, some approximation, is necessary, in the proper planning of irrigation works, as the unit of value is in financial matters. You cannot tell how much water is needed in a particular month, or year, but a great deal of irrigation work has been built in the West with no better basis than simply individual judgment or conjecture. There is a necessity for some engineering knowledge when you come to the question of the disposal of the water that fills a canal, because a great many of the contracts are made perpetual. During the past four years the Department of Agriculture has been carrying on very extensive measurements and has been keeping a continuous record, to determine just how much water has been used, what amount was lost in transit, and how much was actually used on land, and the average for these four years has been remarkably close, over a very large number of measurements in ten or twelve States, showing that the water measured at the heads of ditches varies between four and four and one-half feet. That is, the loss is enough to cover the land to a depth of four to four and one-half feet. Now, to show how far that varies from the statements and estimates on which works have been built, for nearly all of the earlier canals in Colorado the water contracts and dimensions of the canals were based on a requirement of about seven and one-half feet. Some of the more recent contracts have gone just as far to the other extreme, providing for water enough to cover the land to a depth of one foot. There is a large canal company in California which would be very glad to wipe all its contracts off the slate if its customers would surrender them and make a new deal which should promote economy. A great many of those old contracts are based on the acre, without any regard whatever to how much was furnished, and they have all been framed on the advice of engineers: That is just like agreeing to furnish a man with groceries without any estimation as to how much shall be consumed. The man who pays two dollars an acre thinks he must pour on all he can, but the contracts are perpetual and he won't surrender. There is only one kind of contract to make, and that is one which allows each man to pay for just what he gets, and where every consumer can get the benefit of his economy and skill. But there are very few contracts of that kind in the West.

PROFESSOR WILLISTON.—Does that measurement represent one foot per year?

PROFESSOR MEAD.—Yes.

ELECTROCHEMISTRY AS AN ENGINEERING COURSE.

BY C. F. BURGESS,

Assistant Professor of Electrical Engineering, University of Wisconsin.

The justification of establishing a new course of study in engineering schools lies in the demand which the industries make for men having training which such courses offer. The rapid development in the application of electrical energy in producing chemical transformations which has taken place during the past decade has given rise to the new course of study which some or our engineering schools have recently organized or are about to institute, *i. e.*, applied electrochemistry.

Electrochemistry may be considered the pioneer among the various branches of electrical engineering, antedating and making possible telegraphy and other subsequent developments. The popular impression that electrochemistry is distinctly a new field arises from the renewed interest which has recently been attached to it through modern scientific and experimental study, with subsequent evolution of new theories, but more especially from the meteoric growth of what may be called our electrochemical and electrometallurgical industries. Scientific progress in electrochemistry and industrial progress in the same line have not been of the "hand-in-hand" variety, but there has been a considerable degree of independence of one upon the other and the industrial side has undoubtedly made the greater advances.

Modern theoretical electrochemistry as based upon modern research is in a very unsettled and uncertain state, and no theory has been set forth which will satisfactorily classify known electrolytic phenomena or afford a basis for calculation.

The industrial side, on the other hand, has made distinct, material and permanent advance, not so much through our new scientific discoveries as through the application of engineering knowledge to the many and long-known scientific facts which the pioneers have previously pointed out. Many of the laboratory experiments have, through such application, been advanced to the position of industrial processes.

While we cannot deny that scientific discovery is the basis of most industrial progress, we might reasonably expect industrial progress in electrochemistry to continue in the future, even though no new scientific discoveries be made; such progress to consist in the practical application of many discoveries which lie dormant, recorded in the technical and scientific literature and awaiting only engineering development to make them of direct utility to mankind.

In this field we have many illustrations of the fact that it is not the original discoverer to whom greatest credit is due, but it is he who makes such discoveries of direct utility that reaps not only the pecuniary reward but usually has associated with his name the honor of both discovery and of development. The Castner process for the production of metallic sodium is but a reproduction on a large scale of the experiment which Sir Humphry Davy performed nearly a century ago in separating metallic sodium from the fused sodium hydroxide. The McArthur-Forrest process for extracting gold by means of cyanide solutions is based upon the discovery of many years ago that potassium cyanide is a solvent for gold. Many other similar instances might be cited.

The pioneers of electrochemistry include such honored names as Davy and Faraday. Among the more modern ones, perhaps the most noted is that of Moissan, for his extensive work on the electric furnace. Such pioneers have furnished many discoveries which might be worked out to industrial advantage. In the fact that most of the scientific discoveries have not been worked out industrially by the originators we have a striking proof of the saying that "good pioneers do not make good settlers," and in considering the workers in electrochemistry we may regard the pioneers and the settlers as two distinct classes of workers.

The question may arise, "Should our colleges offer instruction with the view of developing pioneers, or of developing settlers?" The answer is, of course, "Both." If the question were to read, "Should our technical schools offer engineering courses in electrochemistry for the purpose of training pioneers or settlers?" the answer would properly be, "The training of the settlers is the primary object."

A considerable amount of discussion has been waged as to what the training of the electrochemist should be, and there has been a great diversity of opinion. The chemist maintains that he should be instructed primarily and most extensively in chemistry, together with various side lines including electrical subjects. The engineer says that he should be trained primarily in engineering with chemistry as a side line. The disciple of physical chemistry says his training should consist in a thorough grounding in modern theories of electrochemistry preferably in the German schools, or next best, by study under a graduate of such schools. The work which is offered in various institutions in this country shows the results of such differences of opinion. One institution places its instruction in electrochemistry in charge of the chemical department and the major part of the work is covered by the field of electrochemical analysis. Another institution places it in charge of the department of physics, holding it to be a branch of science. Another institution has a four years' course in electrometallurgy, assuming that as a broad and inclusive field in electrochemical application in connection with the metallurgical industries. Still another has instituted a four years' course in applied electrochemistry, included as an engineering course and parallel with a course in electrical engineering to a considerable degree. This wide divergence in opinion and practice arises largely through differences of opinion as to what the finished product of such a course should be and through differences of opinion as to what the term electrochemistry comprehends.

There are certain cases where the chemist's view is perhaps best, where the electrochemist's work consists most largely in chemical manipulation in which the electric current is used as an auxiliary agent and in which chemical knowledge is preëminently required.

It appears that, inasmuch as the warrant for establishing courses in electrochemistry arises from the present needs of the electrochemical industries, the courses of study should be such as will best supply men to meet such requirements. This calls for an engineering training; a familiarity with the various forms of energy, hydraulic, mechanical, electrical and thermal; the transmission, transformation and utilization of each, coupled with a sufficient knowledge of chemistry to enable such engineering information to be utilized with the best efficiency.

It was not many years ago that the chemical manufacturing industries were considered as independent of electrical or mechanical power, and chemical processes were supposed to be at the highest state of development when they were simplified to such a degree that machinery and power could be dispensed with, everything being accomplished by purely chemical reaction. The remarkable improvement in the efficiency and operation of the machinery as a substitute or as an aid for chemical reaction, cheapening of processes as regards both labor and material, and the utilization of electrical energy in very many chemical operations, have put the chemical industries on an entirely different basis. They are now preëminently power-using industries. It is this condition which has placed many engineers having a mechanical or electrical training at the head of our largest chemical industries, endowing them with the title of chemical engineers.

In discussing this question as to what the training in electrochemistry should be we must realize that there is the same difference between the term "electrochemist" and "electrochemical engineer" as between the terms "chemist" and "chemical engineer." It is the training of the electrochemical engineer with which I wish to deal.

Electrochemistry is a term which, in its popular conception, may include only a limited field, such for example as electrolytic decomposition. For our purpose it may be given a much broader and more comprehensive meaning, including the following divisions:

Electrolysis of aqueous and non-aqueous electrolytes, transforming chemical into electrical energy, or the reverse.

Electrothermal effects, or electrothermistry, as it has recently been called. This includes all forms of electrical furnace work.

Influence of the electrical discharge upon the decomposition or synthesis of gases.

Electrolytic osmosis, etc.

Electrometallurgy is really a more limited term than electrochemistry, inasmuch as it deals with one or more of the above divisions as related particularly to metallurgical industries.

It is not my purpose to go into detail in the citation of the industries related to the above divisions. Suffice it to say that the various applications make a diversified knowledge a necessity, and the most difficult question in designing a course of study is to get all the apparently necessary studies into the four years, which seems to be the maximum time which our colleges can well set aside for a course of study under present conditions.

In the electrical engineering department of the University of Wisconsin, instruction under the term applied electrochemistry has been offered as an elective for the engineering students during the past eight years. Something over a year ago a four years' course was instituted which has followed to some extent the plan as suggested by the electrical engineering course. A number of students have registered in this course and the various inquiries which have been received from various parts of the country indicate that it is going to be a popular one, and a considerable number of inquiries and requests for graduates from this course have already been received.

The following is the outline of work given the University of Wisconsin in the four years' course in applied electrochemistry.

Freshman Year.

First Semester.

	Hours per Week.
German or French	4
English composition	3
Algebra	4
Descriptive geometry	5
Chemistry, general	3

Second Semester.

German or French	4
English composition	3
Trigonometry and analytical geometry	5
Descriptive geometry	1
Surveying	2
Shop work	1

Sophomore Year.

First Semester.

Analytical geometry and calculus	5
Physics	5

Machine design kinematics	3
German or French, technical	3
Chemistry, qualitative and quantitive	4

Second Semester.

Calculus	5
Physics	5
Analytic mechanics	5
Machine design	2
Chemistry, quantitative analysis	3

JUNIOR YEAR.

First Semester.

Mechanics	5
Physics, precision of measurements	2
Electromagnetism, dynamos, etc	3
Chemistry, chemical analysis	5
Physical chemistry	5

Second Semester.

Applied electromagnetism	5
Materials of construction	3
Chemical preparations	5
Physical chemistry	5
Elective	3
Inspection tour of industrial establishments	

SENIOR YEAR.

First Semester.

Applied electrochemistry	5
Alternating currents	5
Organic chemistry	5
Steam engineering	3
Testing materials	2
Thesis and elective	2

Second Semester.

Applied electrochemistry	5
Alternating currents	3
Electric lighting and power	3
Chemical machinery	2
Elective	4
Contracts and specifications	1
Thesis	4

The first two years' work is practically that required in other branches of engineering, with more chemical work required during the sophomore year, this taking the place of shop work and drafting of the other courses. A considerable amount of physics and physical chemistry appears quite important, physical chemistry including the study of the elements of electrochemistry, together with the theory, as treated in the view of modern discovery.

The above is not set forth as an ideal course, but rather as one which will as nearly fulfill requirements as the present conditions in our university will allow. It is proposed to make some changes in the future and among such changes appearing desirable are the following.

General chemistry should be given as a daily study throughout the freshman year. Surveying is not an essential study and is included in the above list on account of the desirability of making the freshman work of all the courses alike.

During the sophomore year an improvement would consist in making qualitative and quantitative analysis a daily study throughout the year, the chemistry of the junior year to consist in organic chemistry for the first semester and in chemical preparations and industrial chemistry as a daily study for the second semester. Chemical engineering and chemical machinery and appliances might properly be a suitable branch to be followed throughout the senior year.

All of the work in chemistry, physical chemistry and applied electrochemistry consists largely in laboratory practice and it is the time necessary for this work that makes it difficult to include all the studies which seem desirable.

The course in chemical preparations and industrial chemistry as now given is designed with the view of impressing upon the student the matter of cost. Each student makes on a fairly good scale many common chemical products. He is supplied with the necessary raw materials which are charged up to him at current market prices, and the finished product is weighed, analyzed for purity, and the value of this same is credited to his account, at the market rates of this material. He is required to make a report giving a statement of the efficiency of the process, materials consumed, materials produced, waste products, methods of procedure on a large scale, the machinery and apparatus necessary, and an estimate of labor and power. In this manner it is sought to impress the economic questions which enter into chemical work.

It is proposed to assign similar experimental and laboratory work in applied electrochemistry, in which electrical energy becomes one of the important factors to be considered.

THE SUBDIVISION OF THE FIELD OF CHEMICAL ENGINEERING.

BY EDWARD ORTON, JR.,

Dean of the College of Engineering, Ohio State University.

Chemical engineering may be regarded as the economical performance of chemical reactions on a large or industrial scale. The immensity of the field of activity comprised in this definition is apparent to any one who will give it a moment's consideration.

In one sense chemical engineering is the oldest branch of human activity; the one which marks the transition line between utter savagery and civilization. Away back in the dawn of history man was employing chemical arts in the manufacture of pottery, of glass and of metals, and by these arts he has lifted himself up to what he is to-day.

But in the usual sense chemical engineering is one of the most recent and least securely established branches of technical education. The term as yet conveys no very sharp idea of its exact scope to the public, and in some quarters at least, this lack of sharp definition awakens a feeling of actual distrust, as if the chemical engineer was neither chemist nor engineer, but was endeavoring to cover his weakness by a high-sounding title.

If one pursues an enquiry back into the beginnings of engineering education he will observe that civil engineering was the first branch to receive collegiate recognition, and that from the separation or subdivision of this subject into constantly widening fields of knowledge, all other recognized lines of engineering education have come.

Some way back along this line of evolution, we find the beginnings of chemical engineering, in the so-called schools of mines. At one time a civil engineer was thought wholly competent to do any technical work necessary around a mine. With due time to adapt his ideas to the changed surroundings, he could survey in the dark tunnels underground as well as out under the blue sky. With practice he could design and erect any structure required for hoisting and disposing of the output of a mine. By invading temporarily the field of his neighbor, the mechanic, he could crush and prepare the materials won from the bowels of mother earth and bring them, so prepared, to the smelter or refinery. But there he struck an obstacle.

Up to that time no branch of engineering had been taught in colleges in which mathematics, physics and its derivative sciences would not practically meet the needs of the engineer. It would meet the needs of miner as well as of mechanic, shipwright as well as bridge-builder, astronomer as well as surveyor.

The metallurgist has, like the civil engineer, practiced his work as a craft for ages—as a science for a period so short as to seem like days. But at the root of this industry there lies a series of natural facts, for the solution of which purely mathematical or physical training is inadequate, and which brings in the sister science of chemistry.

There has been no time when the civil engineer has been able to step over by easy transition into the field of the metallurgist. In fact, the real mining engineer is to-day, and always has been, a civil engineer who has given his attention to the engineering of mining. But so intimately is the work of winning the crude supplies of mineral wealth associated with the work of treating them, and so often is the art of securing them clearly subordinate to that of using them when won, that both lines of work have been generally practiced as one profession. Most unfortunately this profession has grown to respond to the name of mining engineering. It would have been far more consistent and more successful in the upbuilding of true conceptions if the work had been called metallurgical engineering, and if it had been recognized that the mining and other work required in obtaining and preparing its crude materials was the accessory and dependent craft of the two.

Courses in mining engineering, comprising instruction in civil engineering and chemistry, as parallel and equally important lines, has been a factor in technical schools for a relatively short time. Probably Columbia College, whose school of mines was established in 1864, represents the earliest important work of the sort in America, while Freiburg, in Saxony, was the center of the earliest German educational efforts in this line. The wonderful success which has greeted these schools, and which has put their graduates in the lead in so many other similar schools all over the world, as well as in charge of such important industrial enterprises, is a clear indication that such a combination of training, chemical and engineering, as they gave, filled a great and urgent need in the educational and industrial field.

On account of the priority of its introduction into schools, the great development which it has had in the educational field, the conspicuous service which it has rendered in recent industrial expansion, and the consistent nature of its fundamental chemical ends, it is evident that mining engineering (or metallurgical engineering, as it should be called) will always be accorded the distinction of being the first and foremost branch of chemical engineering.

In fifty years metallurgy has sprung up from the condition of a rude empirical art of small extent, into probably the most exactly scientific and important industry practiced by man. It is since chemistry became the handmaiden of industry, in fact since it has been taught by the schools, so that its applications to metallurgical subjects could be seen and grasped; in short since the superintendents and managers of metallurgical industries began to earn their promotion via the laboratory route, that this most wonderful change has come about. No brighter page in the history of the application of science to industry will ever be written than that which was written by the metallurgical chemists between 1850 and 1900.

If, now, we accept metallurgy as the first well-established branch of chemical engineering, and remove it from our present consideration, what is left?

It will be remembered that we classified as chemical engineering the economical execution of any chemical process on an industrial scale. This does not necessarily include all branches of chemical science. Some are at present purely philosophic and speculative. In others, for instance in agricultural chemistry, the effort of the scientist is directed principally to understanding the nature of the vital process, to recognizing and classifying the wonderful variety of its products, and to determining the conditions of temperature, moisture, soil and food, under which these products can be most plentifully obtained. The marvelous process we call life is the constructive engineer here, and while man can take advantage of its moods and tenses to produce results truly marvelous, he can never control its operations with the exactitude easily secured in inorganic processes.

Similarly in physiological fields of research man does not hope to ultimately manufacture things by the aid of the chemical life-process, except possibly in the way of medical substances. His effort is rather to comprehend, to guard the life-process from interruption, and to hold in healthful operation, rather than to utilize it as a means to an end.

While these fascinating fields of chemical study are gaining in importance and bringing increasing numbers of students into their ranks year by year, there is no reason to think that they are becoming more closely akin to the field we are considering than they now are. They are not engineering, nor ever likely to be.

Out of the formidable array of non-metallurgical chemical industries, there is but one group which admits of ready and consistent classification. This group, comprising the manufacture of clay ware, glass and cement, is called, for lack of a better name, the ceramic group. The name is perhaps unfortunate in suggesting at first only one, and perhaps only a part of one, of the three principal industries represented. But careful search has failed to develop any other English or foreign adjective which may be used with less attendant disadvantage.

The ceramic industries, like the metallurgical ones, have a fundamental reaction in common, and one which does not occur elsewhere in chemical practice, except in an occasional or accessory capacity. This reaction is that of igneous silicate formation. The products of these three industries are silicates. The raw materials may be silicates already, as in the case of clay, or feldspar, or may be any other mineral or metallic compound natural or prepared. But when the product emerges from its bath of fire, it is a new and different substance from when it went in, and generally possessing properties not exhibited by natural silicate materials.

An attempt has been made to set the ceramic industries apart as a separate field of chemical technology, and to recognize this subdivision by providing separate courses of study in it leading to a new collegiate degree. This movement was set on foot by the establishment of a well-equipped department of clay-working and ceramics at the Ohio State University in 1894, and later by the establishment of a course of study leading to an engineering degree in that institution. This action, while it was as vigorous and formal a step towards the end indicated as could be taken by any single institution, and while it has been successful from the beginning, nevertheless stands principally for the personal efforts and influence of the writer, who has devoted his energies to that end for the past eight years. Recently this movement has received some support from other sources. New York State appropriated $20,000 to establish a similar department in 1900, which was located at Alfred, New York. New Jersey appropriated $12,000 for similar purposes in 1902, and the work will be begun at the Rutgers Scientific School, which is the land-grant college in that State. The Iowa Agricultural College at Ames, also a land-grant institution, has entered into this field to some extent, I believe. In England, a school has been established in the Victoria Institute, at Tunstall, and an able man has been put in charge of it. They are now doing very creditable research work there; but the class work is as yet not well developed. In Germany the idea of this classification long ago received endorsement by the formation of trade and technical societies, limited to this group of industries, and later by the formation of trade schools. These schools are arranged on a different conception from the American, and are more like manual training schools than like regular university work. They give but a limited theoretical training, and spend much time on imparting actual skill and dexterity in the various operations used in ceramic industries. Recently, however, a course of instruction in a technical school in Cöethen has been opened, in which work in ceramics is given of a grade as good as that given to other engineering work, and very different from that of the trade schools before mentioned.

While these evidences just cited may seem to show that this subdivision of the chemical field will become a permanent and well-recognized one, it is still fair to say that they do not by any means establish the case. In fact, no public argument has been held on this topic, nor has the subject received consideration among the leaders of chemical thought in this country. Until it does, and until it has in a measure fought its way into recognition, the permanence of this whole idea may be regarded as problematical.

There still remain, after the removal of the clay, glass and cement industries from the field, a very large number of chemical industries. Looking them over, it is in vain that we attempt to find a single fundamental point on which they can be classified, unless possibly that in most of them organic chemistry is essential. There are large industries, such as the manufacture of acids, alkalies, salts, chemical reagents, etc., in which the work is strictly inorganic. But there are dozens of others in which organic work is exceedingly varied and important, as in the manufacture of aniline colors, perfumes, soaps, glycerine, explosives, etc. It seems, therefore, that no general or far-reaching affinities can be shown to exist between the chemical industries which are neither metallurgical nor ceramic.

We have now divided the field of chemical engineering into three parts, metallurgy and ceramics, each of which consists of sharply defined groups of industries, and a third, into which falls the unclassified residue, and which we call general chemical manufacture. Let us see what differences in preparation, if any, are necessary to permit a man to give a good account of himself in these three industries, after leaving college.

Teachers of chemistry and engineers seem to hold somewhat diverse views on this point. These views when crystallized may be said to represent two different plans: First, that advocated principally by teachers of chemistry, in which the student is given a four-year course in pure chemistry and such other subjects as he can find time and energy for. The chemistry is supposed to be entirely without specialization, comprising all branches with entire impartiality. The student would be drilled on chemical principles, and made to work up scientific processes, but these illustrations would be chosen at random from the whole field of industrial and theoretical chemistry, and not with any desire or intention to specialize.

At the end of such a course the teacher anticipates that the student would go into business, thoroughly grounded in chemical principles, but without any capital of trade or industrial knowledge. He would be justly comparable to the graduate of an ordinary academic course, who finds himself at the threshold of life with well-trained tastes, keen perceptions and good reasoning power, but of no special utility anywhere. The mental discomfort of such a position has been keenly felt by thousands of young men, who have given voice to their discontent with this system in no uncertain tones.

The alternative proposition, supported chiefly by engineers and users of skilled labor is for subdivision of the field, with a view of reducing the ground over which any single student must go, and then insisting on some degree of competence in that field from the very beginning. All who bear the name *engineer* have been familiar with this feeling. It is a sort of cult among engineers that they shall not only know how to reason and how to learn, but shall know where and how to start for the attainment of any given goal. This latter ideal finds exemplification in the course of study required for the degree of Engineer of Mines ever since its introduction into the curricula of technical schools, and in the courses of ceramics now established or about to be established in this country. The two courses are parallel in all respects except as to the technical work. They consist of a backbone of engineering, mathematics, physics, mechanics, drawing, surveying and construction. On this as a superstructure, the mining courses give good training in quantitative inorganic chemistry, mineralogy, geology, metallurgy and mining. The ceramic courses give the same training in chemistry, except that the drill is on silicates instead of metals and ores, geology, a little mineralogy, the metallurgy of fuels, and a lecture and laboratory course in the principles and practices of clay-working, glazing, coloring, glass-making, cement-making, etc.

The similarity of these two courses will perhaps lead to the point being raised whether there is sufficient room for this differentiation between metallurgy and ceramics. Would it not be better to avoid unnecessary subdivision and call the whole field metallurgy, especially in view of the numerous points of contact or actual overlap in the two?

As before stated, the fundamental reaction of metallurgy is *reduction*. Any other chemical step may precede it to prepare the oxide for this final change.

This reduction may be simple and easy as in mercury or zinc, or very vigorous and severe as in iron or manganese. It may leave a dry worthless waste, or may produce torrents of fused silicate slags.

Now the fundamental operation of ceramics is silicate formation—a process which involves or assumes oxidation of the ingredients. The ceramist produces silicates as the end and aim of his work. The metallurgist either breaks up and decomposes silicates to get from them their metallic contents, or if he forms them, does so merely for a convenient means of removing them from the furnace. His knowledge of silicates is usually confined to methods of breaking them up, or if forming them, to the ratios within which some three or four cheap and available oxides will unite to produce the most fusible slags. The metallurgist chooses between two silicates for slags that one which will most readily absorb sulphur or phosphorus or anything else he desires to remove. The ceramist chooses for his purposes a silicate which will least readily absorb anything outside of its own ingredients. The two industries are the direct antitheses of each other in almost every respect. Where they happen to employ the same machinery, it is generally to achieve an opposite purpose.

Both use fuel extensively and both subject their materials to high temperatures in large fire-brick structures. But no comparison between the metallurgical furnace and the potters' kiln can be drawn, except that both are tall cylindrical brick structures kept at high temperatures. Even in a regenerative glass tank and a regenerative open-hearth steel furnace the principle is the same as to the furnace, but widely different as to the objects sought.

It is true that in the hands of a skillful and mature man, well trained as a metallurgist, the ceramic field would be easy of invasion, so to speak. Whatever he knew of fuel and its utilization, or of refractory materials, or of silicate formation, would be straight to the point; and, by force of reasoning power from a solid chemical foundation, he could assimilate facts in the new industry rapidly and become competent. But the same might be said with equal truth of the ceramist who desired to invade the territory of the metallurgist. He could grasp far more easily the facts needed in the compounding of the crude coarse and fluctuating silicates used in slag formation than the metallurgist could grasp the delicate and intricate manipulation needed in the control of glazing operations.

While these statements are true for skilled and mature men who have experience as well as training back of them, it is certainly not true of fresh graduates of either course. No school of mines professor is for one moment satisfied with what his students know. In fact, in the face of the enormous increase in the exact knowledge in metallurgy, the professor is now in a constant quandary as to what to teach and what to leave out. How near to competence, even in the line of metallurgy alone, is it possible to bring a student in four years? This is his daily query to himself. And when the graduate steps out into life, how can he possibly fill both fields acceptably, when it has been shown that the task engages the fullest energies for a mature and skilled man? In short, the graduate, be he ceramist or metallurgist, is pretty sure to fall considerably short of his teacher's ideas as to what he ought to know of his own immediate line, let alone having the judgment and aplomb necessary in one who expects to step into the field of another.

The two fields are large enough to permanently support their own corps of specialists. In fact, it is more likely that we shall come to graduating iron metallurgists, and copper metallurgists, etc., than that we shall go towards an amplification of fields now delineated and occupied.

The metallurgical industry produced in 1900 products having a gross valuation of 552 million dollars. Of this about 390 millions were in the useful metals and 150 millions represented the precious or money metals.

During the same year about 180 millions of dollars were produced by the clay, glass and cement industries. We have here, then, an industry of enormous magnitude which is growing proportionately faster than the other, and whose products, even now, reach one third of the total metallic valuation. For this enormous industry, until 1894, not one American technical school gave a single course of study. Not a single college-trained man was acting in this whole country as a consulting engineer, ready to take up the problems and give expert advice in this enormous field. Scarcely a dozen books bearing on the technology of this industry had been printed in the English language. And yet there is absolutely the same reason to anticipate that scientific work would do as much for this industry as for metallurgy, its counterpart, or complement. Truly it seems little short of marvelous that so vast and so tempting a field for educational enterprise so long lay fallow, and even now when a start has been made workers are found to be so few. It is certain to remain second in importance only to metallurgy, and to gain constantly on that. No man is able enough, and versatile enough, to become a specialist in both, even though they be parallel. Hence it seems certain to become a field for chemical engineering, of importance proportional to its industrial standing.

Let us now take up the matter of the training for the general chemical industry. We are confronted at the very outset with the fact that there is no sort of classification possible which will include any large proportion of these residual industries. Further, it is not possible to specialize the student on either organic or inorganic work, for he may be required to be familiar with both or either. Metallurgy and ceramics deal wholly with inorganic chemistry. For their men to spend time on organic chemistry would be folly so far as technical competence is concerned. It would stand on the same plane with biology or literature or any other non-technical subject. Its study would be a very attractive and broadening mental exercise, which would add to a student's capacity for enjoyment, but not directly to his earning power. Not so with the manufacturing chemist. He knows that he is more likely than otherwise to be required to know something of both.

The arguments by which specialized courses in metallurgy and ceramics are justified, in fact demanded, are not so clearly applicable in the case of general chemical industries. It is not by any means to be conceded that the first proposition for a general course should be at once adopted, in which chemistry, not chemical technology, is taught, and in which the graduate could enter no industry with special fitness and could enter any with equal ease. This idea has a strong following among chemists, but engineers are loth to give up the idea of competency for any one who carries their name. One thing is certain. If a student must get the backbone of an engineering education, and must add as a superstructure a broader and more detailed knowledge of chemistry than is needed by the metallurgist or ceramist, and must know the salient facts concerning a large number of unclassified industries, instead of a few which are constant and logical in their relationship, he must either have more than four years in which to accomplish this task or he must go out less competent for his work. There is no escape from this alternative.

As has been pointed out recently by Lachman, there is the widest disparity between the courses of study arranged by those schools which give chemical degrees, either as Engineer or B.Sc. He finds much to criticise in the average chemical course.

Three things seem clear to the writer:

1. The degree of chemical engineer should not be given unless the graduate can reasonably expect to go out with as much competence for his field of work as is found among young engineers in any other course. In other words, hold up the value of the word engineer, and make it mean something to carry it.

2. If the nature of this field is so much more varied and so much more complicated than that of metallurgy and ceramics that equal competence cannot be attained in a course of equal length, then this fact should be frankly admitted and the time increased.

3. The present practice of trying to incorporate both metallurgy and ceramics into a course in chemistry should be abolished. Is not the field large enough and difficult enough without bringing in these branches, upon either of which a man can spend his life work without making scarcely a visible impression? Graduates in chemistry now chiefly find their way into the metallurgical industries—some are beginning to get into ceramics as well. They enter in this field with a heavy handicap, and are apt to cast discredit upon their training by their lack of competence. Four years of special training are little enough to make a metallurgist, but when it gives place to four years of general training over a far wider field the result is morally certain to be unsatisfactory to both employer and employee and teacher. If a student desires to follow metallurgy or ceramics he will find good courses ready to prepare him for the purpose. But if he desires to prepare for the more varied field of general industrial chemistry, he will find enough to do without spending his time upon these others.

The function of an engineering school may be regarded as threefold: First, to teach principles or laws; second, to develop reasoning power; third, to give sufficient familiarity with the field of operations contemplated, so that the application of principle to case shall not be unnecessarily slow, tedious or imperfect—in other words, to give competence. Now no school fully meets these three needs. It becomes a question of judgment how far a school shall carry the student. In the case of metallurgy and ceramics, four years enable us to turn out men well equipped with principles, fairly developed in reasoning power and fairly familiar with their field. In the case of general chemical engineering, four years will necessarily leave a man ill equipped in the third particular, because he has more chemical principles to master, and a more diversified field with which to become familiar. But to assume that because a field is large the effort to cover it should be abandoned, or to assume that competence should be at once abandoned in the case of general chemical engineering, while it is insisted upon for both metallurgy and ceramics with fairly satisfactory results, does not seem to be either necessary or advisable.

Personally, the writer believes that, notwithstanding the great diversity of industries represented in the field of general chemical engineering, it is possible to train men in five years so that they could enter any of these industries fairly well equipped. The operations of the chemical plant are merely the operations of the laboratory on a large scale. If the student be given a good drill on quantitative chemical preparations and has access to apparatus for performing the ordinary processes of heating, cooling, calcination, reduction, oxidation, filtration, lixiviation, etc., in the same general way they would be done in the works, there is no reason why he should not give a good account of himself even in an industry of which he knows practically nothing in the start. But if the alternative proposition be followed, crowding as much as possible into four years and then sending the student out to find his billet, it seems clear that he will start lower and advance slower than if one more year be given in school, devoted to technical rather than general study.

Further, the practice recommended by Lachman and followed by many schools, of crowding in all the chemistry possible, and at the expense of the engineering side of the course, is a fatal mistake. Engineering knowledge cannot be absorbed by mere contact. A young chemist without engineering training who enters a large chemical industry is almost sure to remain a chemist. The man will be promoted and put in authority who joins with a sufficient chemical understanding the power to carry out large schemes and provide new ways for doing things rapidly and cheaply.

To sum up, I stand for a sound course of the essentials of engineering, for all who enter the field of chemical manufacture. On this the chemical superstructure should be placed. The superstructure should be adopted to the end in view. A tripartite subdivision of the field seems the least that is now feasible; future years may witness further subdivision. This division naturally includes the metallic industries as one group, the silicate industries as another—both inorganic—and the residue, largely organic, constitute the third. Reasonable competence can be attained in four years in the first two, and possibly in the last, if it confines its work to its own special field. But an additional year should not stand in the way of making its graduates proportionately competent.

DISCUSSION.

PROFESSOR BROWNE (by letter).—While no one will question the utility of some practical knowledge of applied electricity for electrochemists, the chemist cannot be expected to be also an electrical engineer. Indeed the usual training of the chemist, with the exception of electrochemical analysis, includes nothing of the practical applications of electricity.

On the other hand, the training in chemistry given in most electrical engineering courses is meagre and inadequate for one who may be called upon to take charge of any electrochemical industry.

The two lines of work hardly touch at any point and this fact cannot but make it difficult for the chemist and the electrical engineer to work together to the best advantage. The chemist does not appreciate the difficulties involved in handling and controlling the heavy currents usually called for, while the electrical engineer does not realize the needs of the chemist.

Two ways for remedying this defect may be suggested. First, include the study of electrochemistry in the electrical course and thus enable the engineer to meet the chemist on common ground. (The term "electrochemistry" here includes the industrial application as well as the theory.) Second, offer a course of instruction for electrochemical engineers.

Taking up the second suggestion first. There will certainly be a demand for electrochemical engineers. The training for these should be primarily a course in applied chemistry with a thorough grounding in physics. It should include the theory of electricity, alternating as well as direct currents, electrical measurements, transmissions and distribution of electrical energy, and application and control of electricity in electrochemical operations. Necessarily the modern theory of solution would be an important subject in such a course.

As to the first suggestion, that the study of electrochemistry be included in the electrical course, the writer believes that this subject is becoming so important that no electrical engineer can afford to be ignorant of its principles. This contingency can be best avoided by including in the regular electrical studies a course in electrochemistry. It should cover not only the engineering problem of handling and controlling the electrical energy and the methods and processes at present in use, but also a brief course in the modern theory of solutions. The writer believes that such a course can easily be given in all our institutions. The theoretical part can be handled best by the Chemical Department and the engineering end by the Electrical Engineering Department. This latter part could be made of such character that it could be taken also by the chemical students specially interested. Indeed the whole course could be so planned that it would be suitable for both chemists and electrical students.

Some question has been raised of late as to the advisability of including in the electrical course anything of the modern theory of solution and electrolysis. The results of this study have already been of such great importance that the study itself seems well worth the brief time necessary to gain a fair idea of its teachings. Moreover, the usual electrical engineering course is narrow and the tendency seems to be to still further crowd in practice at the expense of theory. A full-fledged engineer cannot be made in college and it would seem better to be sure of the theory and leave more of the practice to be learned from actual work. This is not only logical but it is more difficult to learn the theory after leaving college than with the aid of an instructor. And further, much of the practice cannot be successfully taught in the class room. Viewed from this point a slight digression into theory does not seem detrimental.

PROFESSOR WILLISTON.—Professor Williston thought the Society was greatly indebted to Professor Orton for his very able presentation of so interesting and important a subject. The speaker said he felt certain that the subject of chemical engineering is going to receive a great deal more attention in the future than it has received in the past. The chemist would not be able to handle many of the problems of the future that he has been able to handle fairly successfully up to the present date, because manufacturing operations are now conducted on such a scale as to make it more and more important to properly determine the most economical methods of handling the material and the most certain methods of getting results. This involves many problems in engineering. He felt that the tendency in chemical engineering is going to be the same as it has been in other branches of engineering, a case of more and more specialization. Just as engineering in general has been divided into a number of fields, he felt sure that we should see a further subdivision here, as Professor Orton had so well outlined in his paper. It seemed, however, to the speaker that there was to-day a possibility of subdividing that field a little further than had been suggested. For example, there is a wide difference between the applications of inorganic chemistry and organic chemistry in chemical manufactures. He believed the field of chemical manufacturing in inorganic branches is one of a great deal of importance. In Brooklyn and New York and vicinity chemical manufacturing of this kind is a very important industry, not involving as much money in these industries as in the industries surrounding Pittsburg, but still a very important work. Professor Williston said, further, that they had had at the Pratt Institute for a number of years some very successful courses in applied chemistry, applied to this group of industries, in inorganic chemical manufacture, and he believed that there was a demand for the same thing elsewhere.

The speaker said there was another group of chemical operations that suggested itself to him, and that was gas manufacture and allied branches of chemistry, which would include, of course, those operations necessary in dealing with the various by-products which were so important, and would probably also include the various chemical operations connected with the refining and handling of by-products of more or less allied substances, such as petroleum and crude oils.

Professor J. P. Jackson.—Professor Jackson said that the tendency to over-specialize during the four years of an ordinary undergraduate course had been discussed to a great extent in these meetings. He remembered that it had been said at the meeting last year that the aim should be to train ''industrial engineers'' in the four years' course, and to give them a sound training in the fundamental principles underlying all engineering—sentiments with which he fully concurred. In illustration of his own attitude he remarked that he had recently received a letter from a young graduate of the Department of Electrical Engineering, under his charge, who had been engaged in electric street railway work, but had recently accepted a responsible position in the civil engineering department of a large steam railroad system. The young man wrote apologizing for leaving his profession or something equivalent. Professor Jackson said he replied by saying that he must be a good electrical engineer, with a broad training, or he would not have been able to grapple with the civil engineering work successfully. Professor Jackson said he considered that the case just referred to indicates the sort of man the engineering schools ought to try to turn out, that is, those who, by reason of broad unspecialized training, can take hold of almost any engineering problem in an able manner.

The speaker, replying to one of the previous discussions of the paper, said that the necessity for a suitably arranged set of electives in metallurgy was apparent. For instance, there is almost a heart-rending lack of possibilities for a man to get training in electrometallurgy. He believed the colleges should carefully deal with that line of engineering, following out, to a certain degree, Professor Burgess' suggestions, but with modifications which would not permit the course to become more special than is at present the case in the general electrical engineering course.

PROFESSOR EMORY.—Professor Emory inquired as to how much of the now recognized courses in mechanical engineering are included in Professor Orton's course in ceramics.

PROFESSOR ORTON.—Professor Orton replied that the course in ceramics in his institution gives the same training in mechanics that is given to all other engineers. This involves two terms of analytical mechanics and one term of strength of materials. In answer to further question, Professor Orton stated that in the senior year of his course one term of experimental engineering, consisting of elementary work in steam engineering, testing of engines and boilers and pumps, installation of shafts, pulleys, belts, etc., was given. The drawing given in the ceramic course begins with freehand drawing and lettering in freshman year, projection drawing, descriptive geometry and shadows and perspective in the sophomore year; in the junior year the only drawing given is the plotting of survey notes and making of maps, and in the senior year a course of ceramic construction, comprising the making of plans and estimates for the construction of kilns, dryers, factory buildings, etc. No machine design is included in the drawing course. Shop work is given in but small amount and late in the course, not from any low opinion of its importance but because of the greater necessity of other things.

PROFESSOR EMORY.—Professor Emory said that the recitation of a little experience which had been told him might possibly lead to some good. In a certain steel business a friend of his had found his place as a chemist, and he told Professor Emory that if he had taken the advice of his instructors, and not neglected taking drawing and shop work, he might now be practically at the head of that concern. Whether it behooves us to specialize to this extent or whether we ought to limit ourselves to turning out a larger number of men in fewer technical specialties is a question of opinion; but here is a chemist with no mechanical knowledge who has come to exceedingly regret his state. If he had taken shop work and machine design and had had some of the training of a mechanical engineer, he could very easily be worth more to himself and his employers.

PROFESSOR MERRIMAN.—Professor Merriman said he wished to protest against statements which seemed to be founded on the assumption that it is the course of study that makes the man. In his opinion it is the way in which the boy studies what is put before him that makes the man, rather than the particular subjects pursued. The idea that one graduate attained success because he studied bridges or machinery, and that another was unsuccessful because he studied them rather than something else, seems to be a mistaken one. It is the spirit of study in the young man, the scientific spirit of inquiry, that makes a good student and gives the training which leads to success after graduation.

PROFESSOR FRANKFORTER.—Professor Frankforter said that he was delighted with what Professor Orton had said; that in his institution for a number of years there had been given a course in chemistry, analytical and applied. This course fitted men largely for analytical work, but it had been found desirable that these men should have some knowledge of engineering, so there had been recently organized a course in chemical engineering, and there had been encountered the difficulty of differentiation. There has been planned a course which would cover organic chemistry, specially fitting men to take charge of these great mills surrounding his institution. It seemed to the speaker, therefore, that we must either organize a number of different courses or have the course for the first year the same, and then to differentiate in the sophomore, junior and senior years, otherwise it would be necessary to give a course of at least five years to cover the ground.

In regard to electrochemistry, Professor Frankforter said he was not surprised that any one should claim this vigorous little infant, and yet he expressed surprise that the electrical engineer should claim it, as he thought it belonged to the chemist. Professor Frankforter thought that if one looked over the foreign electrochemical journals, he would find that where there is one electrical engineer there will be twenty or thirty or more chemists, and that work in electrochemistry is largely chemical at the present time. Professor Frankforter said that he had frequently talked with the editor of the *Deutschen Chemischen Gesellschaft,* and he believed that a good course in physics was all that was necessary in electrochemical work. Professor Frankforter expressed his doubt as to whether that is sufficient, but he thought a man should have a thorough training in chemistry; a special training in chemistry and a short course in electricity, rather than a long course in electrical engineering and a short course in chemistry.

Several of the great electrochemical industries in Germany are organic. Many of the analine colors are now manufactured by electrochemical processes. Therefore the electrochemist should be a thorough organic chemist.

Professor Frankforter said further that he knew the chemist in the great copper works at Butte, Montana, who had only a course in physics and electrochemical analysis. The speaker disagreed with the writer of the paper in saying that a man should be an electrical engineer and have chemistry on the side, but that he should be trained in both, with chemistry perhaps first.

Professor Caldwell.—Professor Caldwell said he wanted to endorse what Professor Frankforter had said. He had always felt that it belonged rather with the chemical than with the electrical department. It seemed to the speaker that the electrochemist did not need to know how to build dynamo machinery, but that not only the electrochemist but every chemical engineer should have a moderate amount of real electrical engineering work; that is, he should not only work with the electrical machinery in the physical laboratory, but should know the general principles regarding the handling of dynamo machinery. The application of electricity on a large scale to chemical processes, however, must be taught, and if the chemical departments are unwilling to take up the burden, it must fall to the lot of the electrical departments.

Professor Burgess.—The criticism which has been made upon our course of study that electrical engineering subjects are recommended as the principal ones for the student of applied electrochemistry to follow will be seen to be unfounded by comparison of the amounts of time devoted to electrical subjects and to chemical subjects. One of the previous speakers has made the statement that the greater part of the electrochemical work in this country is along the lines of organic chemistry. While not denying the desirability of a thorough knowledge of organic chemistry in electrochemical work I wish to take issue with this statement. I believe it can be shown that only a very small percentage of the electrochemical industries of this country are based on organic chemistry, and this certainly holds if electric furnace operations be included as they properly should in electrochemical operations.

It is not necessary that the electrochemical engineer should know how to design electrical machinery, but he should know the principles of operation and management, the advantages in the use of various forms of machinery, the generation, transmission and utilization of electrical energy in its various forms, the properties of constructive materials, etc., and this is information which can hardly be picked up incidentally by students who devote most of their time to the study of chemistry.

SOME ABUSES OF THE LECTURE SYSTEM.

BY A. W. FRENCH,

Professor of Civil Engineering, Worcester Polytechnic Institute.

The lecture system as here considered may be defined as a system of instruction in which the principal contact of students and instructor is in the lecture or the method by which class-room work is restricted to talks and explanations by the instructor, the students taking part only as listeners. Such a definition seems necessary, for many schools have fallen into the habit of speaking of all class exercises outside of the laboratory as lectures even when they are of the nature of discussions or recitations. The writer wishes to consider only the lecture, using the word as above described.

It must be granted that the lecture has its proper place, and that when used in such place it is a powerful agent in a system of instruction. As often used it would seem to be a relic of the days when text-books were few, unsatisfactory and expensive, when the student was compelled to seek information from the savant, who held his knowledge as a private possession. There may be to-day in certain lines of work, on which the post-graduate desires to concentrate his attention, professors or practicing engineers whose personal experience and knowledge of fact or theory give such value to their lectures that nothing could replace them. But if our attention be confined to the four years' course in the engineering school it must be granted that the greater part of the work is of necessity confined to the elements of subjects which are well known, the literature of which is abundant and accessible to all.

The teacher's duty is not to spread facts before the student, but to train him to make use of knowledge, to solve problems, to overcome difficulties and to think for himself.

The principal abuse of the lecture is its too frequent use. Too often the only work of the instructor is to meet his class three times per week and recite to them a certain quantity of matter, which in some cases may be found in a standard text-book that each student should own as a part of his library, and the term's work is closed by a three or four-hour examination.

Considering the nature of the major part of the work of the engineering student and the present condition of scientific and engineering literature, it would seem to be an abuse of the lecture to depend, to any great extent, upon it as a means of instruction.

It is open to objection for the following reasons:

1. It is a waste of time to present by word of mouth that which can be presented in print. An hour's lecture can not place one third of the amount of matter before the student that he can easily read in the same time. That hour should be of far greater value to the class than the mere receiving of the subject matter for their future consideration. Much of the detail of a subject, which must be considered before the real problem is reached, requires none of the instructor's aid for the student's comprehension. It does not appear to be economical for the teacher to repeat to

each succeeding class these details, as the ancients handed down their lore before the age of writing and printing. Indeed one objection to the lecture is that the lecturer often overlooks some of these same matters of detail and proceeds on the assumption that every one was born with a knowledge of such matters. If he dispenses with the test by quizzing his class, he will not become aware of his mistake until the examination reveals the fact that the present class know no more than the first class he ever lectured to.

2. The student should give his undivided attention to the thoughts which are presented in the class-room and he can not do this if he is required to take notes which are at all complete. Without proper notes he has not the material for the careful deliberation which should follow his first acquaintance with the matter presented in the lecture.

It is said that the American student is deficient in the art of taking a lecture as compared with the European student. It is not surprising that the American boy naturally shirks needless hand work that could be more efficiently performed by a good machine.

It is a depressing sight to see thirty or forty men attempting to take notes in an imperfect manner when a copying machine could run off complete sets for each student in a few minutes. Possibly there is good discipline in such work but it can not be in the line of engineering education. If the class-room work is worth the presence of the student it should demand his undivided attention, not as a machine but as a brain.

3. If anything like the same ground is to be covered

by the lecture as it is practical to cover by the aid of good text-books and the recitation, the lectures must move along at a pretty good rate of speed, with very little repetition. It is well known that the points of difficulty for different persons considering the same subject are not identical; one should have more discussion on this point and another on that. The follower of the lecture must pass on with the lecture, leaving some essential point dim and foggy, to be straightened out later if he can make it out from his notes. With the text before him, he may profitably put his time where it is most needed, and finally, as the last resort, the class work should clear up those difficulties which he has not been able to master alone.

4. The student should have the benefit of the classroom work *after* a careful study of the subject rather than before. He should be trained to defend what he believes he knows and should be able to stand a rigorous cross examination without confusion. Every one who has been a student will recall many instances where he has received more benefit from the successes or failures of his classmates in some well-conducted quiz, than he did from his book or his professor. Such exercises are usually lacking from the lecture course because of lack of time.

Some advocates of the lecture system have asked, "Do you succeed in obtaining clear answers to your questions and is the recitation of any benefit to the student who does not happen to be the target?"

In answer it may be said that if the exercises have usually been confined to lectures and only an occasional quiz be held the result is usually heart-rending but it offers striking proof of the fact that something is wrong with such method. If a young man can not give an intelligent statement of the work he has been devoting his energies to, it is time he was dropped from the class, did better work, received better instruction or had more practice in the use of the English language.

It must be admitted that the easiest and most comfortable method for an instructor to conduct a class is by means of the lecture. There certainly is a sense of satisfaction to the teacher who has clearly put a complicated proposition before a class with careful wording, perfect order of treatment and logical development. He may feel that no one ever stated the matter quite so clearly before, and he is sure that none of his listeners could fail to take in the full understanding of the matter. But let a quiz be given upon that same work and the usual result is that the instructor finds that the statement he has been some days, or perhaps months, in working up and condensing is not quite clear to the boys who never met the proposition before.

The lecture system fails to furnish the frequent tests that should be applied to the student's work. A very valuable part of the training which the student should receive is the necessity of doing steady and regular work with a requirement to be met and filled. The students in engineering schools are said to be half boys and half men. The man knows what he is there for, but the boy has his doubts. If he can satisfy the law by attendance on lectures and the test is far away the boy can hardly be expected to do the vigorous work that he should do each day. Often the student remarks in explanation of lack of power in certain lines, "We had Prof. D. in that subject and he gave us good lectures but he did not hold us up to any requirements until the examination; then we got hold of the old examination papers and a book one of the fellows knew about and we crammed up enough to pull through." And we call such treatment a course of instruction.

Large classes sometimes prompt the instructor to a use of the lecture because of the difficulty of properly conducting a recitation with such classes. If it is granted that the recitation following the use of good text-books is the best way to handle a small class it is an abuse of the lecture to resort to it simply on account of the large class. Institutions with many students should be able to do as thorough work as the smaller institution. Money can provide a teaching force large enough to handle the class in reasonably small divisions. The economical use of the student's time is of the greatest importance. Nothing confided to the care of the school is so precious as the time of the student and nothing is so easily squandered.

It is not unusual for an instructor using the lecture to devote too large a proportion of the available time to the presentation of some phase of a subject in which he is especially interested. The same instructor would hesitate to design a text in which an undue amount of space was devoted to his fad, but he unconsciously does this when talking to his class.

The dislike of many a teacher to the placing of text-books in the hands of his students and confining his attention to the work of training the student by discussion of the work, sometimes seems to be due to a false pride which feels that it lowers the dignity and reputation of the teacher to make extended use of some other man's work. To witness the disgust of graduates who sooner or later find that the Professor's lectures, of which he may retain straggling notes, has for years been in print in good form, in other words that his instructor has taken hours of his time in reciting borrowed matter to him, would do much to cure that false pride.

Some may say that no text-book can be up to date, that the subject matter is constantly changing and that the lecture is the only means of keeping up to date. This may be true for a small percentage of the work, but does not hold true for the greater part of the undergraduate work of the engineering school.

Probably no text-book on any subject will exactly meet the ideas of any two instructors; but if, from the many valuable books now published upon most engineering studies, one can not be found that will serve as a ground work upon which the student may build and to which the teacher may add his own personality, it would seem as though that particular teacher's mind was cast in too odd a mould to make a successful instructor.

In the cases where no satisfactory text can be furnished to the students, why should not the methods of our engineering societies be followed and a copy of the instructor's paper be given to the student, that he may listen intelligently and discuss with the instructor?

The writer is aware that many teachers disagree with him in regard to what he considers abuses of the lecture system and he would be pleased if it could be made clear to him that the lecture is the most efficient method of conducting class work, for it would mean much less labor for him. Careful observation as a student and as a teacher, and close contact with many students and graduates has so far led him to the conclusion as above set forth.

DISCUSSION.

PROFESSOR SPANGLER.—Professor Spangler said that a good many years ago he came to the conclusion that a poor text-book was a good deal better than a good lecture.

PROFESSOR C. M. WOODWARD.—Professor Woodward said he was very sure that a good text-book is a great deal better than a poor lecture.

PROFESSOR EMORY.—Professor Emory thought that the requirement of having the student take his own notes is of considerable importance to the student; it is largely a course in English at the same time. Another point is that possibly a much larger amount of material can be brought to the attention of the student by lecture than by any other way. All perfect instruction deals with a subject in at least three ways, once in the lecture room, again in the draughting room and again in experimental work. Steam engineering is usually taught by these three methods, or rather this method of three parts.

PROFESSOR ALLEN.—Professor Allen said that it was probably known to many members of the Society that he is personally in general sympathy with the paper; that in general he is opposed to the lecture system. Those members of the Society who were in Chicago when the Society was born may remember very well the animated discussion that took place on this particular point. All may not remember however the remark made by that great early master of teaching, De Volsen Wood, "Since we have two feet, what is the use of compelling ourselves to walk on one?" The speaker said he personally believed that most of the substantial work in teaching engineering should be done by text-book, but under certain circumstances the lecture is valuable. No one method will answer; that is, neither method alone; but both should be used judiciously. Some very fine teachers are poor in recitation work, but very good in lecture; and some very excellent teachers are not good as lecturers but very good in recitation work and we cannot quite afford to do without the work of either of these classes of men.

Professor A. W. French.—Professor French said he did not want to have the idea go forth from his paper that he did not use the lecture. He certainly did use the lecture himself, but it is only the abuse of the lecture system that he wished to point out. In reference to the point that had been made that the students received practice in English by taking notes in lecture, he said he had not observed this, and that a student usually fails in being able to get up on his feet in class-room and say what he means when he may be able to write it fairly clearly. In text-book work the point of view that the writer has is made clear, but sometimes another point of view is better and the speaker said he had sometimes observed that the book explanation fits one half of the class and if the professor supplements it by his own explanation it will often enable others in the class to see the matter in the light in which the instructor has put it. There is, therefore, an advantage in both systems.

PROFESSOR SPANGLER.—Professor Spangler thought that if the students are to be obliged to take down lectures or notes of lectures they should be taught stenography.

INTERCOLLEGIATE ATHLETICS.

BY CALVIN M. WOODWARD,

Dean of the School of Engineering and Architecture, Washington University.

I need no statistics to prove that engineering schools and engineering departments as a rule take no active part in intercollegiate athletics. There may be exceptions, but we never hear of the Massachusetts Institute of Technology, Troy, Worcester, or Stevens, on the gridiron, on the diamond, or in regattas. How the teams are made up at Harvard, Yale, Cornell, Wisconsin, Michigan and Pennsylvania, I do not know, but I suspect that student engineers are generally "too busy" to find time, and too interested in their work to feel an overmastering craving for athletics, so the athletic spirit which occasionally bursts into flame is gradually quenched by the steady stream of "lectures" and "laboratory calls."

Doubtless we have all been somewhat to blame in this matter. We have seen so much that the student ought to get and to do, and so much that the future engineer ought to know and to be, that we have preempted the students' hours of play and recreation as well as their hours of study, and have overlooked the plain duty of attending to the physical natures and appetites of the young men in our charge.

It is my conviction that we have made a serious mistake. To a certain degree we have defeated ourselves. Faculties and boards of control have great responsibilities in the direction of athletics, which responsibilities in a vast majority of cases they fail to meet properly. Sometimes they grossly mismanage matters, but more often they neglect them and try to ignore them. They let things drift. They admit in a half-hearted way that physical culture is a good thing, but they discourage every development of athletics under student management, while they inaugurate no adequate management of their own. In many cases athletic managers, supported as they are by strong popular favor, are a sort of terror to tutors and professors; they compel them to assist or at least to wink at deception and dishonesty.

It is useless to expect clean athletics when the members of the faculty participate in or condone fraud and unfairness. I do not willingly admit the shortcomings of college officers, but their own confessions can not be gainsaid. I know of no more corrupting influence upon students than a dishonest faculty. You would be astonished and mortified if you knew the extent to which professors in reputable institutions make false returns of the standing of players supposed to be indispensable to the success of a college team. The excuses they offer are that they must make allowance for different standards and hence some ''diplomacy'' is necessary to secure a fair game; and secondly, that the demand for leniency is so strong that it becomes a duty to the institution they represent to exercise a discreet indulgence. It is extremely discouraging, it is said, to make a poor showing in what are popularly held to be manly sports, through the maintenance of high standards of scholarship. In one institution a student is held to be disqualified by dropping below an average grading of 60 per cent.; in another he is allowed to "pass" on an average of 30 or 40 per cent. Similarly the phrases "college grade," and "post-graduate" mean little or much according to usage. It is clear that the temptations to place new and unwonted meanings to the word "conditioned" are very strong.

Has not the time arrived for a general conference of representatives from all institutions for higher education, whether literary or technical, for the purpose of formulating rules, and adopting uniform standards in so far as they bear upon the question of eligibility to athletic teams? All admit that high standards are necessary in determining a man's worthiness to be proclaimed an attorney, an architect, an engineer or a physician; while a more moderate standard may be admissible in the general studies which are regarded as in no way professional. A university may require a passing grade of 40 per cent. in its college of letters, but insist upon 60 or 70 per cent. in its schools of engineering, law and medicine. Evidently there should be no such discrepancy in determining athletic eligibility for intercollegiate games.

Local conferences have already been held, but I suggest an effort to bring together all institutions east, west, north and south, and if possible adopt standards and rules that all can faithfully observe. My object to-day is to lay before you some considerations in favor of systematic management of both domestic and intercollegiate athletics in every school or college of engineering, and to submit some practical suggestions in regard to the latter feature.

I have recently given some thought to manly sports, and I venture a few words in regard to their value in every scheme of all-round education. * * * * *

I close with some practical suggestions based upon my experience as chairman of an athletic board, and upon a study of the conditions which obtain elsewhere.

The following rules and definitions are respectfully submitted.

ELIGIBILITY.

1. To be eligible to membership in a team representing the institution one must be a *bona fide* student, doing full work as a "regular" or a "special."

2. His average scholastic standing must not be less than 60 per cent. and in no single branch or study shall his record for the last quarter be less than 50 per cent.

3. If a "dropped" student, or a "not-promoted" student, he shall not be eligible till after one year, either in the same department or in a different department. (For example, a student not promoted in a school of engineering can not secure eligibility by withdrawing and entering the college of letters or the law school.)

4. He must not have been a representative college athlete for four years either in one, or more than one, institution. The four years begin with the date of his first appearance on a representative team; no allowance is to be made for not playing, except in the case of exclusion under rule 3.

5. He must hold a certificate of actual physical soundness, and a muscular development sufficient to justify his taking part in a proposed athletic contest; this should be signed by the gymnastic director if a

physician, or by the highest medical authority connected with the institution.

6. He must be able to swim if he proposes to row in a college boat either for practice or in a regatta.

7. He must not be in arrears to the local athletic association.

8. He must not be receiving and must never have received compensation for playing or teaching others to play athletics. Compensation is here held to include not only salary, but rebates and remission of fees, ordinary personal expenses, a share in the gate money, or financial aid in any other direct or indirect form.

9. He must be free or acquitted of all charges of improper and ungentlemanly conduct in his athletic record.

All the above rules shall hold for substitutes and ranking candidates for positions on a college team.

MISCELLANEOUS RULES.

1. An athletic committee appointed by the president or elected by the faculty shall represent the faculty and board of control in all athletic matters. The chairman shall certify to the eligibility of every man on the team, and whenever asked for it he shall furnish a certified copy of the athletic record of any man on the team.

2. The athletic committee shall pass upon the time, place and conditions of a proposed intercollegiate contest, and shall determine the amount of absence from college exercises a member of the team may have during a season.

3. The athletic committee shall at all times be free

to examine and audit the accounts of the treasurer of the athletic association.

4. Contracts for coaches, trainers, grounds, etc., shall not be valid until approved by the athletic committee.

5. Except for practice and informally, *i. e.,* not for public exhibition, a university team shall not play with teams from preparatory schools, nor with teams from non-educational institutions.

6. No university team shall play formally or informally with a professional team or with a team containing professional players.

7. A university team shall not play with the team of another college or university unless every member of the opposing team be eligible under rules substantially the same as above.

8. No personal expenses for travel, clothing, training or medical attendance shall be paid for students not enrolled as members of teams and substitutes.

9. If a member of a team becomes ineligible for any reason, he shall at once be dropped from the team and a promotion shall be made from the waiting list.

10. If a player be dropped from a team on account of delinquency or dishonorable conduct, he shall at once cease to wear athletic honors in the way of numerals or letters.

11. Members of a university team shall not have played on a team of similar character during the preceding summer vacation.

12. Managers of teams shall be elected by the athletic association.

13. Each team of actual players shall at the end of a season elect the captain for the succeeding season.

14. Managers, in consultation with the athletic committee, shall make up the schedule of games for the season.

15. Captains, with the approval of the athletic committee, shall make up their teams from the eligible lists.

The object of all athletic organizations shall be understood to be chiefly the following, arranged in the order of importance, the most important first.

(*a*) Physical culture with the mental alertness and moral stability which follows in its train; consequently the greater the number and variety of athletic games and teams the better.

(*b*) To meet the normal and healthy demand of young men for manly sports, for recreation and relaxation, and to relieve the tedium of much study.

(*c*) To foster to a reasonable extent local pride and emulation, to create an *esprit de corps,* and to promote harmony and good fellowship between students and faculty and between different departments.

(*d*) To advertise a college or university by arousing interest among preparatory students and others who otherwise might never be attracted to the advantages and enjoyments of higher education.

To secure these objects every student should be encouraged on entrance to submit himself immediately to a physical examination, and with the advice of the physical director or the athletic committee not only begin regular gymnastic practice, but join a branch of the association devoted to systematic practice in some athletic game.

Every program of hours in a school of engineering, as well as in a college of letters, should recognize the demands of rational athletics.

DISCUSSION.

PROFESSOR C. M. WOODWARD.—In conclusion Professor Woodward spoke as follows:

The expenses of college athletics are largely paid by the gate receipts. I dislike exceedingly the idea of gate receipts. I wish the athletic department of every university could be so endowed that all legitimate expenses of the athletic department could be paid for out of its income, and that whenever it sees fit to invite a set of players from another institution, or to accept an invitation to play away from its own institution, the expenses should be paid out of the income and not out of "gate receipts."

The idea of gate receipts puts the thing altogether on a wrong basis. As to the gross expense of different kinds of games for the year Mr. Walter Camp, of Yale, says that foot-ball costs between $15,000 and $20,000, wholly met by the gate receipts; base-ball costs $9,000 to $12,000, met by gate receipts; track athletics, about $4,000, all met by gate receipts, except a small part. In Washington University all our track affairs are complimentary, and I believe that West Point and Annapolis play with each other on the same basis. No gate receipts stare a man in the face; one can go there as an invited guest. This is my idea of athletics. I have read some suggestions in the way of rules. I hope the time will come when every healthy whole boy will have a share in athletics and when we shall eliminate professionalism and everything that affiliates us with professional sports.

PROFESSOR J. P. JACKSON.—Professor Jackson said that Professor Woodward's story of how he had been managing athletics deserved rich returns. The only point in which Professor Jackson differed with the author of the paper was the question as to whether we do or do not become absorbed in athletics. The speaker believed that if Professor Woodward should visit many of our engineering colleges in the midst of the foot-ball season he would, at almost every place, find that athletics was filling the minds of the students to quite an extent. Intercollegiate athletics is believed in at most universities giving engineering courses, and the engineering instructors are very frequently put on the faculty athletic committees. There was one point which the speaker wished to suggest with reference to the rules which had been read, and that is the need, additional to those named in the paper, for a report from each athlete immediately before each athletic trip, as to his scholastic standing. His current standing, as shown by this report, should be used as a basis for granting permission to enter a contest. He said that no student having a standing of less than 60 per cent. in a current subject should be permitted to leave the university for athletic purposes. He said that at the Pennsylvania State College such a rule has been in force for several years with a minimum grade requirement of 65 per cent. Though this has been found somewhat difficult to adhere to, it has been clearly shown that many a boy who would otherwise put his whole energy and thought into athletics is, by the "current-standing rule," compelled to study during the period of his particular athletic interest. Making him keep up to grade means that he will do some studying, and even a man who otherwise would not succeed in the work will thus often become a fair student and learn regular habits of study.

PROFESSOR WALDO.—Professor Waldo said that this was a question which had interested him for a number of years, and it had been his fortune to help work out the rules of which mention had been made, and to spend quite a number of days in their consideration. At present it happened to be his fate to be a sort of appellate court for a number of institutions in the West. The speaker said that this had made it necessary for him to give pretty close attention to the details of this question of intercollegiate athletics and he wished to say first that Professor Woodward's position is as sound as it can be. The speaker said that the desirability of intercollegiate athletics is past question and, so far as the various rules which have been proposed are concerned, he thought no one present would disagree with any of them. The only question is what can be done that will be accepted cheerfully by students and lived up to. We are bound by conditions to quite an extent, and we cannot move faster than we can cause the student body to move with us and whatever is done must be done with reference to what we can attain. The speaker was sure that most people who have been at work on the question have exceedingly high ideals. They believe that athletics can be the incident and not the purpose of college work, but there are things with which we have to contend. The triangular league in New England, for example, is disrupted over the question of whether a man is a professional base-ball player or not, and when we see an old college taking one position on that question with the whole of its student body, and another old New England college taking exactly the opposite side upon the question—a question that seems to be perfectly plain—we must come to the conclusion that there are things underlying the whole business that are difficult to get at. The desire to win is a very serious evil in our intercollegiate athletics. It may be that it can never be controlled, but the speaker believed that faculties should occasionally make themselves a bit unpopular in their attempts to control things and keep them straight. Professor Waldo said he thought the tendency was altogether to excess, and that there was need of preaching moderation. When a student visits another institution and says, "Well, we all pay our men, just like the rest of you, but nobody can find it out," and when this feeling is through and through a student body so that they are hypocritical in all their actions—they want to seem to be perfectly good as far as outward appearances are concerned but with all sorts of duplicity underneath—it then becomes a question as to whether we are not educating in the wrong way. Faculties must stand for what is right, and they must, in many instances, stand in a very unpleasant position, and must be ready at times to be unpopular among their students. The speaker thought there was to-day more reason for this than ever before, because there is a tendency to let the students control the business. It is not the majority who are to blame. The majority everywhere are in favor of that which is right, true and fair, if one gets right down to it, but there will be a small coterie of the student element, perhaps 10 per cent.

or 15 per cent. of the whole, who, by their influence and professions of interest in their institution and by various tricks and devices, will get control of the wires and do things which they claim are for the interest of the institution, securing for it championship and fame. If we can find some means of bringing the good men to the front in all our institutions then we shall have the question pretty well solved.

Professor Jacoby.—Professor Jacoby said that at Cornell they have a number of able professors who have given much attention to the subject of athletics from the time they were students, and they have endeavored, as far as possible, to create and uphold right ideals and develop the work in the right direction. However, any one familiar with the athletic situation at that institution must recognize that there is a decided difference between the standards regarding the navy and those of the foot-ball, base-ball and other teams. The speaker, therefore, wished to call attention to the great importance of the personal attitude of the coach employed. Every student in the navy knows that when C. E. Courtney gives any instruction regarding his duty that it is final. His standards regarding scholarship and morality are high. If any professor should intimate that a member of the navy was not doing good work that student would be quietly informed that he is no more needed around the boat house, and if any intimation comes to the coach regarding the low moral standard of any student on the crew, he is instantly dismissed. Every member of the faculty realizes that the influence of the coach for good scholarship is of an excellent character.

PROFESSOR R. S. WOODWARD.—Professor Woodward spoke as follows:

"I would like to speak briefly in commendation of the paper. We would all be very glad to hail the day when such wise administration could be brought to bear in all our educational institutions. I think the experience of any man over forty years of age is such as to lead him to commend rational athletic sports. There are, however, a few points in our colleague's paper that need to be controverted.

"The first one I note is this: that we Americans are degenerating, somehow. I cannot believe that. We read much of it in the press, but I am inclined to think it is an almost self-evident humbug. Statistics show that the average age of the American is increasing. Our friend Professor Merriman read a paper a year or two ago showing that our average age has increased quite appreciably in the past century. That idea is contradicted also by the law of evolution. We do not so suddenly degenerate.

"My second point is as to the outcome of athletics as they are administered at present in our schools and colleges. It seems to me that a few moments' reflection will lead us to the conclusion that athletics are practised, as a rule, by the wrong men. The men who play on the teams are generally the men whose minds need to be cultivated. The man whose muscle needs to be cultivated most is barred out; all he can do is to stand by and whoop. I may say, too, that so far as my personal observation goes, although the facts may be far different elsewhere, I am reminded of the story of the geologist whose students would come to him with tales of strange discoveries, and he would say, 'I am very glad that you told me about this, for if I had seen it myself I would not have believed it.' These stories which we hear of the great advantages of athletics seem to me something like this. My own experience is that the effect of athletics is very demoralizing to our engineering students. Our best athletes will come to my lectures in mechanics and sit and sleep through a whole year. A few years ago a gentleman who had charge of the foot-ball team in an Eastern institution came to me after the season was over, and after the season for mechanics had largely lapsed, too, and enquired if he could not be passed in the subject. He said, 'I have been doing a good deal for the institution; we have raised $52,500 from gate receipts,' and he took out of his pocket a beautiful gold watch and said, 'Just see what the alumni have given me for this work.'

"Now, when a young man can neglect all his studies for two or three months and yet have the praise of the alumni and get a $250 gold watch and then come to the professor and ask to be passed, there must be something very wrong. I told this young man that we had no such option in mechanics, and he has not passed yet. There are many cases of that kind. These men, who are often the poorest students, are usually the heroes, for a time, until the average collegian gets the wool pulled away from his eyes.

"I speak with some degree of feeling on this matter, because men who have boys to educate have given hostages to the schools and colleges. We can never get over this difficulty without taking the bull by the horns. We must put a stop to the gate receipts.

Think of half a dozen young men having charge of the receipts and expenditure of $50,000 to $100,000 a year! It is an outrage. We are the people, members of faculties, who are mainly responsible for this state of things. We must not only have such rules and regulations as Professor C. M. Woodward has given us; it is easy enough to have rules; but we must live up to them. There are, unfortunately, many in our faculties who wink at these things—college professors, eminent men, who condone all kinds of crookedness in athletic affairs. It is our duty to muster courage enough to stamp out professionalism, but we shall never be able to stamp it out until we are bold enough to say what we think.

Professor Spangler.—Professor Spangler spoke as follows:

"I have listened with a good deal of pleasure to the paper. It reminded me of Dr. White's paper on the same question. The speaker said that athletics is a good thing, but the university sports are not athletics, they are professionalism, and nothing else. I agree with this. I do not mean that the men are professionals in the sense that their rules say they are professionals, but when you keep men for months and months on a special system of training, and then charge so much to see them perform, it is professionalism, pure and simple. It is a thing which we ought to get into shape, especially for our engineering students. We don't take proper care of the boys physically, and it is almost impossible to do anything for them in this direction. It is practically impossible even to have their eyes examined. If we are going to train men, we must take care of them physically, and you can not do it with the present system of athletics. Each institution must work out the problem for itself. One of the evils of the present system and one of the reasons why our intercollegiate sports are in their present condition is because the alumni of each institution believe their concern must win, whether or no, and they are ready to wink at almost anything that may be done in order that the best possible teams shall play. It is not the student body. They don't want crooked things done, and I do not believe the faculties want crooked things done. But I do know it is a fact that 'we must win, whether or no,' and that there are $60,000 or $70,000 or $80,000 to be contributed every year by somebody, and the alumni make up the amount if there is not enough, and they will take a little more than belongs to them of the control of athletics. I believe it is a fad, and will die out in its present shape.''

Professor C. M. Woodward.—Professor Woodward wished to say that he was deeply grieved at the experiences related on his right and on his left, and that so far as his institution was concerned, no student low in his work in mechanics, or in anything else, was allowed to play on the teams.

OVER-DEVELOPMENT IN ENGINEERING LABORATORY COURSES.

BY F. P. SPALDING,

Professor of Civil Engineering, University of Missouri.

The great importance of laboratory work in all lines of scientific study and its absolute necessity to any properly organized course in engineering have been the subject of frequent discussion before this Society, and are so generally conceded as to need no comment at this time.

A large development has taken place during the past few years in laboratories for engineering work. In nearly all engineering schools of good standing laboratories have been installed for the purpose of illustrating and emphasizing the class-room work in certain subjects, as well as to give practice in conducting tests and facility in handling instruments and the reduction and interpretation of results. In a number of institutions also large experimental equipments have been added, intended for the instruction of advanced students and for research.

All of these things have their legitimate uses and are both desirable and necessary in order to secure the best results in engineering education. As is apt to be the case, however, when development is very rapid, there seems to have been an over-development in this direction. Too great stress may be laid upon this work, it may be employed outside its legitimate uses and may be extended to a point where it usurps the time which should be devoted to more fundamentally important matters.

This over-development is not confined to engineering work, but is even more marked in some courses in general science, and is particularly noticeable in the science courses in some of the secondary schools. Great stress has of late very properly been laid upon the importance of developing laboratories of science in the high schools, and efforts to make use of these laboratories and give prominence to this feature of the work have frequently led to elementary courses being given almost exclusively in the laboratory, losing to the student that grasp of his general subject which should be derived from systematic class-room work. It is, however, with engineering laboratories only that we are concerned in this paper, and it is the purpose to enumerate a few points in which the development of laboratory work may not be conducive to the best results in engineering education.

In the first place, it may be remarked that, in undergraduate courses, efficient laboratory work must be based upon, and carefully coördinated with, class-room work in the subject treated. For the most part such work must be intended for illustration, to enable the student by actual contact with materials and machines to see for himself the operation of mechanical laws. This tends to fix principles in the students' minds and gives force and meaning to class-room teaching. But in some instances laboratory courses seem to be getting away from this purpose. We find elaborate and systematic courses in mechanical laboratory having no special relation to the other work of the student. It is frequently necessary to proper administration that the laboratory courses be conducted independently of class-room work, often by different teachers and under separate management, and it sometimes follows that the laboratory courses are developed as ends in themselves, the object being rather that of perfecting the student in laboratory methods than the illustration of class-room teaching. As an illustration one instance may be mentioned in which a course in mechanical laboratory included work in hydraulics, measurements of the flow of water over weirs, through pipes and orifices being made, as well as tests of wheels and meters, while the students taking the courses had received no instruction in elementary hydraulics, but followed detailed directions in making the tests and substituted their observed values in formulas given in the laboratory manual to obtain their results. Such work becomes merely mechanical and has no meaning to the student. Sometimes, also, it is so extended as to occupy an undue proportion of his time. This tendency is perhaps more pronounced where extensive laboratory facilities offer opportunity for advanced instruction and research, and the importance from the point of view of the laboratory man of training men in the elementary courses by a systematic instrument practice to become skilled observers becomes very great.

In engineering laboratory courses, where provision for many students is to be made, efficient and economical administration requires very careful organization of the work. It is not usually feasible to conduct each branch of the laboratory work in connection with the class work in the same subject, but laboratory work relating to a number of subjects is grouped into a single course. A definite scheme of experiments is laid down to be followed out by each student, instructions being given for the conduct of the work and forms for the reporting of results. When carried to extremes and arranged with special reference to accomplishing large results in the laboratory this is apt to lead to such an elaborate systematizing of the work that it becomes merely mechanical on the part of the student. Apparatus is given him all set up and arranged for a particular experiment; he has only to pull a lever, or open a valve, and the machine starts. Certain gauge readings, measurements, temperatures, etc., are to be observed and recorded in columns provided for the purpose on the forms used in reporting results. Certain combinations of the observed values are put in other columns as indicated on the forms, and final results are worked out by formulas given for the purpose.

In some instances experiments of this kind might be carried out by one who did not know what subject he was investigating.

It is always desirable that laboratory work be conducted in an orderly and systematic manner. Students should be taught to schedule properly their observations, to keep clear and concise notes, to tabulate and to discuss intelligently and report results. This requires order and system in the arrangement of their work, but it requires also responsibility on the part of the student for the order of observation and form of report, and while proper system in the work and proper forms for reports are essential to the best results in such work, they should not be so elaborated as to make it unnecessary for the student to think.

The attempt to introduce experimental research into undergraduate engineering courses may easily lead to a serious waste of the student's time. Undergraduate students have not that grasp of engineering subjects necessary to enable them to do original work, and where independent research is introduced into their courses it should be carefully limited to subjects with which the student is familiar or with which he may reasonably be expected to familiarize himself within the limits of time at his disposal. Such work commonly consists in carrying out a scheme of observations outlined by the instructor and requires only skill in manipulation and observation. The use of a large amount of the student's time near the end of the course, when time is of most value, in attempting to execute an elaborate series of experiments, the full bearing of which the student does not comprehend, is certainly of little benefit. Such work leads to habits of careless thinking and superficial reasoning.

It is highly desirable, *if it be feasible,* to teach the student how to investigate a subject by giving him some practice in such work, but the work given for the purpose must be very limited in extent, simple in character and fully under the control of the instructor. It involves investigation outside as well as in the laboratory, and the most important part of it is to secure proper discussion and report of results.

The use of the time of students in making commercial tests in the laboratory should be permitted with great caution. It is to be feared that the practice has sometimes led to serious abuses. It is rarely the case that such work can with propriety be substituted for the regular work of the course.

The development of large laboratory equipments with facilities for research offers a very attractive field to graduate students. It seems evident, however, that in some instances such work is carried far beyond its reasonable limits of usefulness. Most of the students who take graduate work lack the training and experience necessary to enable them to expend profitably a large portion of their time in making an experimental research. They have but a very elementary knowledge of engineering subjects and need development in many directions. The work is not suited to the capacity of the student. Young men sometimes spend a large amount of time in carrying out extensive experiments without any adequate conception of what they are doing. In published results of such experiments, the writer's lack of acquaintance with the subject under investigation is frequently very marked, important factors are omitted in discussion and erroneous conclusions drawn. Frequently such work consists simply in the mechanical execution of experiments outlined by an instructor. Sometimes it may even degenerate into an easy method of getting a second degree.

The experiments themselves may be of value, although commonly they are not, and may be well executed, but they do not represent a profitable use of the student's time. If such work is to be of any real value, it must teach the student not only to manipulate experiments and take observations, but to investigate a subject, which is quite a different matter. This involves usually collateral study of the general subject and the bearing of the experiments upon it, as well as advanced general study in some particular branch of engineering. The difficulty with such work, even when well executed, is that if it accomplishes anything it requires an undue proportion of the student's time.

In developing a laboratory for purposes of instruction the selection of equipment is a matter requiring very careful consideration. The mistake is frequently made of installing too large and complicated machines. Usually a number of small units which can be freely placed in the hands of the students are what is needed.

It is natural that every teacher having charge of a laboratory should feel the desire to make original investigations, and added to this desire is the pressure upon him in consequence of the demand of the authorities of his institution that he do something to attract public attention. An experimental investigation which can be reported in society proceedings or in some technical journal may be of value to him in divers ways. It is often expected that upon the installation of a small laboratory a stream of results will immediately begin to flow, and the effort to meet such expectations sometimes causes the equipment of a laboratory in a manner that is not conducive to good results in instructing students. It may sometimes require considerable courage in the expenditure of limited funds to keep the needs of the students always in view.

The value of a laboratory as an advertisement for the institution possessing it is very frequently a matter of considerable importance which must be taken seriously into account in its organization. The possession of a well-equipped laboratory for student instruction is very properly a strong card for any engineering school and if, in addition, the organization and equipment are such as to admit of making important research, it becomes of still greater value to the reputation of the school. It is to be remarked, however, that those features of laboratory which are most effective as an advertisement are not commonly those which are of most use for laboratory purposes, and it is greatly to be feared that in some instances the desire to attract public notice causes the incorporation of some expensive features only calculated to serve this purpose. The possession of unusual machines which may be exploited in the newspapers or shown to visitors with a catalogue of the remarkable investigations which *might* be made with them is sometimes very attractive. It is so gratifying to be able to exhibit an apparatus with the remark that "it was made for us in Switzerland, a similar one is in use at Munich, but this is the only one in this country," and hear the admiring visitor exclaim, "Just think, the only one in the country, isn't it lovely and complicated!"

Apart, however, from the buncombe apparatus to be found in some laboratories, there seems to be a tendency toward the excessive increase of laboratory appliances. The effort to keep up a continual publication of researches, with the introduction into the courses of student researches, causes a large increase in laboratory apparatus intended for all sorts of experiment. Much of it is devised without reference to the value of the work to be accomplished and considerable ingenuity is sometimes expended in finding subjects for investigation and inventing complicated appliances for doing quite useless things.

This tendency is unfortunate because it belittles genuine investigation and lessens our appreciation of the value of the work of the laboratories.

These laboratories are now a most important feature in engineering education. The value of an engineering course depends largely upon the efficiency of the laboratory instruction, and it is of prime importance that the laboratories be so equipped and operated as to secure the best results. To this end it is essential that the laboratory man, although largely concerned with the construction and operation of apparatus, keep in view the fact that his work is intimately connected with that of other departments of instruction, and that, while an effort should be made to teach the student to be skillful in the manipulation of apparatus, and accurate in observation, these things are not in themselves the most important object in laboratory work.

REPORT OF COMMITTEE ON ENTRANCE REQUIREMENTS.*

In making the present report it may be of interest to review briefly the work of the Committee in successive years since its appointment at the Brooklyn meeting in 1894.

In that year circulars were sent, first, to heads of colleges and schools giving instruction in engineering subjects, asking information as to existing entrance requirements, and second, to select secondary schools, asking replies in regard to facilities and expressions of opinion as to various questions connected with admission to engineering colleges.

In 1895 a preliminary report was presented based on the replies to the above circulars, and including tabulations of the requirements of one hundred and nine colleges:

As to entrance conditions;
As to admission by certificate;
As to uniformity of requirements;
As to changes of requirements.

In 1896 a second report was presented including a fuller analysis of the material collected in 1894, and, in particular, a classification of colleges into five groups on the basis of entrance requirements; a tabulation of the number of colleges requiring particular subjects; a table of subjects required by 25 per cent., 50 per cent., or 75 per cent. of the colleges reporting; a tabulation as to entrance conditions; a tabulation as to admission by certificate; statements in regard to assistance to preparatory schools; considerations determining changes of requirements; individual expressions of opinion; an analysis of replies from schools with particular reference to the following: the proportion teaching advanced subjects; length of course; definitions of entrance requirements; desire for uniformity; admission by certificate. The report further contained a general statement of principles and a series of conclusions and recommendations.

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* The names of the members of this Committee appear on page v.

In 1897 an informal report was presented and the Committee was made a Standing Committee to carry out the recommendations of the previous year.

In 1898 a second circular was sent to colleges included in the 1896 list asking for criticism of the statement of principles for admission by certificate embodied in the previous report and for information as to changes in entrance requirements since the earlier tabulation. At the meeting of that year the Committee presented a third report based on replies to this circular and the question raised by the Committee of attempting an expansion of its work in the direction of formulations of requirements in particular subjects accompanied by an increase of the size of the Committee. This question was referred to the Council and ultimately answered in the affirmative.

In 1899 no report was presented in view of the brief interval since the action referred to by the Council.

In 1900 an informal report was presented calling attention to the organization and plans of the College Entrance Examination Board of the Middle States and Maryland.

In 1901 a fourth circular was issued to members of the Society containing formulations of the following entrance subjects:

Algebra (elementary),
Algebra (advanced),
Plane Geometry,
Solid Geometry,
Physics,
Chemistry,
English,
French (elementary),
French (intermediate),
German (elementary),
German (intermediate),
History,
Free-hand Drawing.

At the meeting of the Society no formal report was presented other than the text of the above circular.

Replies were received from representatives of about thirty-five colleges.

It must be admitted at the outset that the significance of any inferences deducible from the replies is seriously impaired by a misunderstanding of the inquiries themselves on the part of many of our correspondents. In spite of the fact that the circular letter sought criticism of definitions and not change of the list of requirements of any institution, the replies to Question No. 3—"What is the probability of the acceptance of the above formulation by your institution?" were repeatedly of the form—"We require it now," or, "We cannot require this subject," and entirely inconclusive as to approval or disapproval of the formulation as such. It seems, therefore, unwise to attempt to make specific quantitative statements in regard to these more or less ambiguous answers.

The following criticisms among others are embodied in various replies. It will be observed that some of these apply rather to the choice of subjects defined than to the definitions themselves.

(1) *Algebra,* (2) *Advanced Algebra:*

That elementary algebra end with quadratics;

That permutations, combinations and logarithms be omitted;

That the importance of imaginary numbers be emphasized;

That plane trigonometry be made an entrance subject rather than advanced algebra;

That partial fractions be added to the advanced algebra formulations;

That determinants be omitted;

That greater emphasis be laid on definitions.

(3) *Plane Geometry,* (4) *Solid Geometry:*

That geometry of conic sections is preferable to advanced algebra;

That grade of work or time required should be indicated.

(5) *Physics,* (6) *Chemistry:*

That the importance of magnetic field of current and of Faraday's Law of induced currents be emphasized;

That the division of levers into three classes be omitted;

That electricity and magnetism receive more attention;

That some of the experiments are unimportant or even trivial;

That more attention be given to dynamics;

That the formulation is adapted to scientific rather than engineering students;

(6) That the formulation is too comprehensive;

That (5) and (6) are too difficult for most schools;

Doubt is expressed as to the value of secondary school work in these subjects.

(7) *English:*

That the relation through character drawing, pictures of life or studies of humanity and human possibilities to actual practical life and living be added.

(8 and 9) *French,* (10 and 11) *German:*

Writings from dictation is criticised as useless or worse unless the teacher is a native, and exception is taken to some of the texts for reading as difficult and to others as juvenile.

(13) *Free-hand Drawing:*

That model drawing and free-hand lettering should be preferred;

That the instruction and exercises should be wholly in the direction of pure drawing rather than in teaching details which properly belong to applied drawing.

On the whole it seems clear that our engineering colleges have little to criticise in the formulations for English, French, German and history.

At this point it is important to consider the efforts of other educational agencies in formulating definitions of entrance requirements in the literary subjects just enumerated. It is the belief of the Committee that, for the definitions of these subjects, the engineering colleges have no occasion to differentiate their requirements from those of other colleges or to refuse to fall in line with any broad movement of the National Educational Association, for example. In mathematics, chemistry, physics and drawing, on the other hand, the situation is distinctly different. These subjects, except the first, are either not required by other colleges or are of relatively slight importance to them. In the determination of any definitions for general acceptance, the interests of the engineering colleges should, therefore, be most carefully guarded. It is the opinion of the Committee that its further efforts should be concentrated in the direction of securing any needful and practicable improvements of these definitions and, on the other hand, their adoption when thus improved by the engineering colleges. We, therefore, recommend the passage of the following votes:

1. That the Committee be authorized to request the National Educational Association to appoint a committee of conference on formulations of entrance requirements in mathematics, chemistry, physics and drawing.
2. That the Committee be authorized through a sub-committee of three to participate in such a conference, and to prepare revised formulations in these subjects.

In case these votes are passed, the committee will endeavor to be represented at the Minneapolis meeting of the National Educational Association.

DISCUSSION.

PROFESSOR C. M. WOODWARD.—Professor Woodward thought the time had come when throughout the country there could be some recognition of manual training in the preparatory course. That it is recognized at some institutions, for instance at the Lawrence Scientific School manual training is recognized in securing admission, and he thought that the Committee, in order to encourage manual training in the secondary schools, ought to consider whether the time has not come for a general recognition of it in some form, enough to give it a standing in all communities.

PROFESSOR WALDO.—Professor Waldo believed manual training helps towards advanced standing in technical schools as now constituted and is not a subject relating to admission only.

PROFESSOR C. M. WOODWARD.—Professor Woodward said it seemed to him that educational shop work is something that belongs to the preparatory school, and that, although it is in the curriculum of many an engineering school, he understood it was there because it is not in the secondary schools, and that as rapidly as the latter can take charge of it they should be allowed to do so. He thought they should be encouraged in this direction.

PRESIDENT FLETCHER.—Professor Fletcher said he was acquainted with one such school where the work is given to the younger classes with good results.

PROFESSOR TYLER.—Professor Tyler said he thought the motion implied recognition of manual training rather in the sense of including it in the list of possible entrance requirements. It was not intended to recommend it as an absolute requirement for any institution. It is included in the list of elective entrance requirements in some colleges.

PROFESSOR SPANGLER.—Professor Spangler said the tendency in the East is to admit men to college on the point system, on examination in certain essential things, and then a requirement of a certain number of points out of the things that are non-essential. In looking over the field it seems important that a man should be able to present for his admission to college those other things which he does in the last three or four years in the fitting school in order that the total number of points may be made up, and it seems to be rational that, as many men come from manual training schools, their work in wood and in iron, forge shop and foundry, should be given its proper place in making up the proper number of points, and it is desirable that this should appear in these definitions of requirements.

Professor Spangler said, further, that the question of definitions of entrance requirements had been met at his institution, and it had been shown to be desirable that some concrete definition should be given as to just what is meant by each particular point.

Professor Flather.—Professor Flather said that at the institution with which he is connected there are fifteen full-year subjects required for admission, eight of which are definite and the other seven may be offered from a list of a dozen or more subjects, among which are shop work, drawing, astronomy, zoölogy, botany, history and the various languages; and that it did not seem desirable at this time to single out shop work as one of the very many subjects which are offered in the various engineering schools in the country, any more than to single out any one of the other subjects which are offered in the same way, botany or astronomy, for instance. That the work of the Committee previously has shown that there are over one hundred subjects in the schools which are required, and we are taking eight or nine common subjects and are trying to get down to a common basis of definition. That is all we are after now.

It seemed to the speaker undesirable to single out shop work in preference to many of the other subjects which might properly be defined and put in this list; that we should keep the list as it has been given us, and get together on that first, and later on it may be feasible to make an additional list and define that.

PROFESSOR SPANGLER.—Professor Spangler said that botany had been defined as to the amount which should be presented, primary and intermediate French and German, chemistry, physics, and many subjects with which engineers have nothing to do, and it seemed to the speaker that this very subject, shop practice, which is a matter of considerable moment, has been dropped entirely; that the associations of colleges and schools in the East and Middle States have entirely ignored the fact that there are such things as manual training schools. The speaker thought it desirable that, as quickly as may be, we should get the manual training work where we can take care of it.

PROFESSOR TALBOT.—Professor Talbot said that for several years until last year the University of Illinois had among its electives of entrance requirements the subject of manual training, but that it was found that the best manual training schools, including the two manual training schools in Chicago, teach manual training well enough to be applied upon the work in shop practice in the engineering courses, and that other schools were doing so little or so poorly that their work in manual training was not acceptable for entrance. The speaker thought, therefore, that some standard should be made which would allow the schools to know what was expected in such a subject.

PROFESSOR C. M. WOODWARD.—Professor Woodward said he still thought that manual training is the one characteristic of those courses of study which are specially preparatory for engineering. That the others are not specially characteristic, and he thought, therefore, that the time has come when recognition should be given to the subject and he accordingly made a motion to that effect, which motion was adopted.

EXCESSIVE DIFFERENTIATION IN ENGINEERING COURSES.

BY EDGAR MARBURG,

Professor of Civil Engineering, University of Pennsylvania.

The subject of specialization in engineering courses may be presented in numerous phases calculated to give rise to prolonged and inconclusive discussion. If attention be confined, however, to its salient features a substantial unanimity of opinion will be found to prevail among engineering teachers. This is manifest from a comparison of the engineering curricula at different institutions. There are, it is true, occasional tendencies towards specialization to an extent which most of us, perhaps, would deprecate. Such instances are, however, exceptional; the curricula, on the whole, exhibit a remarkable degree of accordance.

It should be stated at the outset that the present discussion will be limited to a consideration of the question in its bearing on courses in civil engineering in the commonly understood scope of that division. The aim will be to keep in view average, present-day conditions, rather than conditions more or less ideal which may or may not be realized at an uncertain period in the future. It will accordingly be assumed that the prescribed requirements for admission to the engineering course are such as can be fairly met by the average high school in our larger cities, and that the length of the course is four years. These conditions, fairly characteristic of our better engineering schools, will tend to restrict debate to definite and somewhat narrow limits.

It will doubtless be conceded that the first two years should be devoted mainly to language and science studies, with especial emphasis on mathematics, as the indispensable groundwork for the later technical subjects. The program may also advantageously include various courses in drawing, descriptive geometry, surveying and elementary mechanics. It is believed that this represents fairly the usual curriculum for the first two years. Nor is it easily conceivable how, under present conditions, this program is susceptible of improvement in any essential particular.

I shall not assume to designate more definitely the particular subjects to be included in this first half of a four-year course in civil engineering; still less to specify the relative time to be devoted to each subject. Within reasonable limits these matters must be governed by attendant circumstances and individual judgment. There are, for example, some who hold that all students in civil engineering should receive practice in shop work, and make provision accordingly during the first or second year. Others claim that such work, to the extent to which it can be introduced, is of little or no permanent value. There are again those who, conceding the desirability of such instruction, consider the time element prohibitive. And, finally, there are some who, endowed perhaps with a keener insight or a larger vision, avow their own uncertainty. What man, or tribunal of men, can assume to settle such questions with confidence and precision? And who, indeed, will insist that they should be settled to a nicety?

In a general way it is true, however, that the subjects commonly prescribed for the first two years are of such fundamental and far-reaching importance, that there can be little thought of specialization. While it is conceivable that certain minor options may be safely offered, the curriculum in all essential features must be a rigid one, or the students' interests will inevitably suffer.

In the upper years the course naturally grows more uncompromisingly technical. The cultural subjects are sacrificed to the relief, usually, of the student, though possibly to his ultimate disadvantage. However that may be, the more immediate technical needs are so numerous and apparently so pressing that it seems hazardous to pursue a different course. Moreover, it is necessary to make provision during this period for a group of collateral subjects which in the aggregate make no inconsiderable inroads on the limited time available. It is believed that no plea for differentiation can avail to justify the excision of such subjects as astronomy, metallurgy, mineralogy, advanced physics, and the law of contracts, however much opinion may differ as to the time that may properly be assigned to these topics. The recognition of geology and assaying, however desirable, appears less essential. Again, any projected scheme of specialization in civil engineering, aiming to exclude instruction—elementary though it be—in steam engines, boilers and pumps, and in applied electricity, seems fairly open to serious criticism.

Coming now to what for present purposes may be termed the purely civil engineering subjects, and leaving from account those covered during the first two years, it may be reasonably maintained that every course should include the theory of mechanics of materials, framed structures, railway and highway construction, hydraulic works, masonry and foundations, and a study of the physical properties of the materials of construction. But instruction in theory is largely misdirected unless it be duly supplemented by design and laboratory work. Experience has shown that it is possible in no other way to invest theoretical study with definite meaning to the student; to transform seemingly abstract and abstruse principles into glowing realities calculated—under competent and inspiring leadership—to arouse the student's interest to the point of unfeigned enthusiasm. By a judicious apportionment of time the principal technical branches may each receive this vitalizing touch, to the great profit of the student. But the program thus supplemented leaves obviously scant room for specialization. Under favorable conditions it may be rounded out by a limited number of free electives among subjects of less general importance to the average practitioner, such as geodesy and cartography, railroad economics, river and harbor works, stereotomy, the bacteriology of water, special lines of municipal engineering, etc. It is believed that in such limited measure, and in such measure only, may undergraduate specialization be permitted without detriment, and possibly with some advantage to the average student. On the other hand, specialization in which the elaboration of one or two branches entails the suppression or mutilation of other important subjects, not absolutely indispensable to the narrow end in view, is looked upon as a grievous wrong to the student, and one of which he will soon be made aware in after life. It is sometimes said that there is a popular demand for such courses, with which the schools must reckon. The writer has seen little or no evidence of such demand. But, after all, a scheme that has intrinsic merit need not be bolstered up by such an argument; and in the absence of such merit the plea itself falls to the ground. It is believed that no apparent popular demand will serve to justify the establishment of highly specialized undergraduate courses; and it is gratifying, therefore, to observe that the schools themselves have not yielded to this temptation in any marked degree.

The fact that most engineers find it expedient ultimately to confine themselves to the practice of some single specialty may be adduced as an argument not *for,* but *against,* similar differentiation in the preparatory courses. Every specialist should possess a fair knowledge of kindred branches. Without some breadth of view he cannot hope to rise to eminence. The greater the difficulty of acquiring such collateral knowledge in practice, the greater the need of its presentation in the schools.

Again it may be asked, how many engineering students have their immediate professional future safely predetermined even three months before graduation? That the proportion is exceedingly small, there can be no doubt. It may be safely affirmed, further, that the average undergraduate is incapable, by any rational process, of arriving at his choice of a specialty. Hence, the more varied the course, the better the opportunity of determining his preference. Otherwise he is like one obliged to make a choice between untasted dishes, guided by instinct alone. And he who hazards the choice of a highly specialized course is surely less fitted for employment in other lines should he discover upon graduation that he had erred in his fancied preference, or should he fail to find a ready opening in his chosen field. And lastly, it is held that no wiser provision can be made against the vicissitudes to which an engineering career is peculiarly liable than may be found in the broadest possible course of preliminary study.

That specialization in engineering education is becoming increasingly important is by no means denied. But in the writer's view its place is not in undergraduate courses. Its legitimate province is to be found in graduate instruction, and there no limits need be set to its intensity. But schools not thoroughly equipped for this responsible work had better not attempt it. Graduate courses, if offered, should be truly worthy of the name. They should appeal to men in practice as something worth striving for. Their value should be absolutely beyond question. This means they must be conducted by an adequate corps of able and experienced specialists, as for example, in our best schools of medicine. In the writer's judgment the smallest number of engineering schools professing to give graduate courses are really fitted for such work. The result is seen in somewhat nondescript fifth-year appendages of doubtful value attached to four-year courses of unquestioned excellence.

BY C. M. WOODWARD,
Dean of the School of Engineering and Architecture, Washington University.

Professor Woodward said that he agreed very heartily with Professor Marburg's paper, and his last point, on which he intended to speak, that during the undergraduate course attention should be largely given to fundamental principles and to subjects that are common to all departments of engineering; and that specialization belongs in the graduate school. The speaker thought that there should be no research as such in the undergraduate course, as it seemed to him that there it is premature and out of place. The first point he wished to make is that even the separation of the courses should not take place very early; he was not in favor of their taking place until the end of the sophomore year. He said he was strongly opposed to the system in the Institute of Technology where it may take place in the middle of the freshman year, as the students do not know their own minds or abilities well enough, and they do not know what the future has in store well enough to make the differentiation, and that any separation at that time is quite sure to involve loss. There are certain subjects every engineer should know, not only mathematics but mechanics, and they should be made the backbone of the course; then descriptive geometry and a knowledge of electricity as now developed, to a certain extent should be in every course. The speaker said that the testimony of the old graduates of his institution is that we should be sure and put the fundamental things in, in any event. He supposed that perhaps 50 or 75 per cent. of the graduates are at work in lines other than those which they followed in the schools: the civil engineer is in mechanical work, and the mining engineer is in civil work, and they change without any trouble; that is a proof of their good training; a young man who is prepared to open up a new field at the end of his undergraduate course is prepared to take up almost anything, not because he knows it but because he is capable of knowing it; when a man begins too early and leaves out some of the essential steps, he makes a mistake that he cannot outgrow. So the speaker was very much in favor of a late selection of his course.

BY WM. T. MAGRUDER,

Professor of Mechanical Engineering, Ohio State University,
Columbus, Ohio.

This is a subject upon which much has been said at previous meetings of the Society, and one which seemed to our president to be of such vital importance to the cause of the best engineering education that it has been given a place on the program again this year. Last year Professor Nagle presented a paper on the "Dangers of Excessive Specialization," which was heartily commended and quite thoroughly discussed by the members present. The writer would call attention to the fact that, having decided that excessive specialization is not wise in undergraduate engineering courses, the proposition which is now before us is that excessive differentiation also has its evils. That such excessive differentiation does exist can be proven by the large variety of engineering degrees which are now offered as the prizes to be won as the results of courses of study in branches of engineering which differ in principle but little the one from the other. From the statistics recently gathered by your committee it will be seen that more than sixty different degrees are offered or have been given by the one hundred odd different engineering colleges of this country. The fact may also be shown that excessive differentiation has its evils by consideration of the number of institutions having an enrollment of less than fifty students and yet having three or more different engineering courses.

In the question of specialization in undergraduate courses, the writer is of the opinion that the pendulum has begun to swing in the opposite direction and that, in an increasingly large number of our institutions, the decision as to the choice of which branch of the engineering profession the boy desires to follow is left until he has mastered the first year of the course, rubbed off his freshness, and forgotten some of his high school habits. The writer believes that this is a step in the right direction and trusts that more of our colleges will change their courses so as to permit the student to gain more maturity of judgment and a broader training in the fundamentals of a general education and in the culture studies before he is required to decide on the specialty of his life work.

But the excessive differentiation in undergraduate courses which is here referred to is that of courses differing but slightly the one from the other, each with a name and most of them with a degree offered for their completion. One hundred years ago engineering was taught only in military academies; then, the civilian decided that he wanted to follow the work of the army engineer without being compelled to get his training at West Point, and Rensselaer Polytechnic Institute was established. Later, some of the civil engineers made machinery their specialty and became mechanical engineers; or else, adapting the methods of the civil and mechanical engineer to the uses of the miner, became mining engineers; and now, mining engineering is divided into mining proper, metallurgical engineering, and ceramic engineering. Metallurgical engineering now receives a degree and is being divided into steel and iron work, aluminum, lead and zinc, and the metallurgy of the precious metals, and the micro-structure of metals generally. Having differentiated these subjects one from the other, there is no telling how soon degrees will be manufactured which will more or less accurately represent the differentiation of the work of an *under*graduate who has specialized in one branch of metallurgy rather than in another. The same is equally true of the profession of civil engineering; and we may expect before long to see the prospectus of some college which will offer the undergraduate degree of bridge engineer, railroad engineer or municipal engineer, just as the degrees of sanitary engineer and topographical engineer are now conferred.

The present tendencies in this matter among our engineering colleges seem to be towards, first, increasing the number of undergraduate courses to suit a very limited demand—courses having less than a dozen students scattered through the four years of the course, and an enrolment of less than two per cent. of the whole number of engineering students. This is true of both large and small institutions. Second, of making specialists rather than engineers, and tradesmen rather than professional men; men who are trained but who are not educated, men who can do some one thing—make a neat and possibly an elaborate drawing with a fancy title for example, but who are innocent of having much, if any, accurate and working knowledge of the underlying principles of the design. Third, a decrease in the amount of time devoted to general or culture subjects, and even to the pure sciences. The so-called professional subjects having crowded out these latter, it follows as a matter of course that there should be distinctions and differentiations made among them. Possibly the writer, as one of the results of his recent study of the statistics of engineering education, may see this question differently from some of the other members of the Society, but he believes the facts will justify his conclusions.

Will it not be well for educators and boards of trustees to call a halt, or at least to consider most carefully the further multiplication of undergraduate courses and technical degrees for which many of them have neither the necessary teaching force nor the requisite means to provide either competent teachers or suitable equipments? And again, are we not lowering the standing of our profession not only by suggesting further differentiation, but by not protesting against it?

The solution for this difficulty, which has gradually grown up with our engineering courses, is the establishment of a three- or possibly a four-year course in culture studies and in general engineering for the bachelor degree, to be followed by a two-year course devoted to as much specialization and as minute a differentiation as the ability of the student and the facilities of the institution in trained specialists and engineering equipments will permit.

BY C. FRANK ALLEN,
Professor of Railroad Engineering, Massachusetts Institute of Technology.

Preliminary to the reading of his discussion, Professor Allen remarked that it was very interesting to him, having the last paper on the subject, to note how differently the subject was approached by the different gentlemen who had already spoken on it, and what different things are found in the paper to which these discussions refer.

Professor Allen's discussion read:

No one should feel called upon to defend either excessive specialization or differentiation, or excess in anything. One may, however, safely oppose the attitude of a paper whose title is "The Danger of Excessive Specialization" when that paper states that the "common course should extend through the junior year," the paper clearly referring to differentiation between civil, mechanical, mining, electrical and similar branches of engineering. Years ago the fixed classical course constituted practically the only higher education available, and was a necessity, as the foundation, for educated or well-trained men of every class. After a while something more specific and direct in usefulness was found necessary in the preparation for engineering work. Scientific schools came early in being but the school of general science fell short of the mark and the engineering college was the response to the demand, and of its success this Society is but one among many evidences. The basis for the engineering college is that theory can be taught most effectively where brought into immediate connection with its applications; and with this proposition early differentiation is in harmony, and is a natural outcome in the continued development of the engineering college. Apparently the best early foundation work for the engineering courses comprises mathematics, physics, chemistry, drawing, and later, mechanics. But following the preliminary training in these subjects, will surveying prove as valuable to the mechanical engineer, even as training, as does mechanism, or is mechanism as necessary and as valuable to the civil engineer as his surveying? Must the mechanical engineer use and extend his drawing on maps of land surveys and the civil engineer upon details of machinery? Shall the chemical engineer use the applications of chemistry in assaying and the mining engineer in industrial chemistry? Why should the mechanical engineer apply his descriptive geometry in stereotomy, and the naval architect spend his time running in railroad curves? Isn't it wise for the civil engineer to use his mechanics to a very important degree on structures, while the mechanical engineer is busy with machine design? The fact is that there is a great variety of engineering subjects in which the opportunity for effective training, as training, is amply sufficient. There exists in fact nothing which can be called a standard course in engineering. It is easier to suggest a course in engineering (general engineering) than it is to determine what shall constitute such a course. Imagine, if you will, that the following professors: In mechanical engineering, Thurston of Cornell; in mining, Richards of Boston; in civil engineering, Merriman of Lehigh; in electrical engineering, Jackson of Wisconsin; in architecture, Ricker of Illinois; should be called together for the purpose of arranging a standard course for four years, which should constitute a satisfactory preparation for mechanical, mining, civil, electrical engineers, and architects, with the further understanding that it must be suitable for chemical engineers and for naval architects, although these courses should be unrepresented on the Committee. Imagine their difficulty in trying to determine what to leave out from what now appears necessary, and which now would require not less than ten years of a student's time. Then consider, if you will, how great the general demand would be for a civil engineer, or for a mechanical engineer, the graduate from such a course, as compared with the man who now receives the specialized course. Would the former student be trained deep enough in any direction to satisfy the actual and the necessary demand, at the present time? The real danger, to the mind of the present writer, is not that the engineer will be trained too far in some one direction; it is rather that in the effort to train broadly an all-around engineer, he may receive a smattering of too many things and fail to get sufficient of any one thing to have done him much good. Furthermore, not only are many of our engineering colleges carrying on more subjects at one time than is really desirable, but in addition, some of the courses are too short to receive from the student the attention necessary to secure good results. This is particularly true of subjects given outside of the department in which the student expects to graduate; and this in cases where the teacher is definitely efficient. Furthermore, the stimulus or interest brought about when the student finds himself really at work in the department becomes a fair argument in favor of early differentiation. Not only must theory be connected with practice to have the proper effect, but beyond this the training in any direction must be carried far enough in its applications to illustrate methods of dealing with engineering questions and thus educate the student in the power of attack, a result which is not reached when a hasty and not infrequently a superficial view of many subjects is necessarily taken. In almost any engineering course there is more danger of defects from lack of depth than from lack of breadth. Any man of fair ability, well trained in any course in our best engineering colleges, can be trusted to give a good account of himself if he is called upon to work in other lines; will the same man trained less deeply give on the whole an equally good account of himself? The most enthusiastic advocate of the paper of last year on the danger of excessive specialization first expresses his "hearty commendation of it from beginning to end." He also takes the ground the student then (at the end of the junior or senior year), but not before, "is probably competent to judge whether he is going to be a civil, mechanical or mining engineer." He then further states himself as "entirely in favor of the practice of Stevens Institute, which gives a severe electrical course, but does not call its graduates electrical engineers. It gives its mechanical engineering graduates very little civil and mining engineering." He calmly shuts his eyes to the fact that, while he cannot trust the student to choose wisely his course, civil or mechanical, until the end of the junior year, yet Stevens Institute, for mechanical engineers only, compels this choice in advance even of entrance.

If this procedure is all right for Stevens, why not for Troy, whose course is essentially a civil engineering course? If the student is not too young to determine which of these to select, how about Cornell, where the College of Mechanical and the College of Civil Engineering are distinct? Then how about a host of others where a half year or a year or more is given to students in common? Is this excessive specialization? It hardly seems so; neither is it excessive specialization if a divergence is made in favor of railroad engineering or sanitary engineering, or mill engineering, or chemical engineering, or naval architecture, or many other options which it is possible for students to select in many of our larger and stronger engineering colleges. The only necessary test is this: Does the course provided give substantial training to the student? If it does, the special direction taken is an obvious advantage. In the Massachusetts Institute of Technology, which the present writer entered as a student three years after it was opened, the engineering courses at the start were the same for all students as far as the end of the second year, and with many studies common during the third and fourth years. It was then actually true, for it happened that a student could and did follow mining engineering through the third year, and completed the entire course in civil engineering in the fourth year by making good only in stereotomy, and in a very short course in spherical astronomy; to-day some divergence between civil and mining engineering is made as early as the middle of the first year. The tendency towards earlier specialization is evident in all courses and a recent letter of inquiry to the departments had called forth the answer that the requirements of the various courses make the early differentiation a necessity and that the results are not unfortunate but are on the whole satisfactory. The change has been in this case a development without anywhere a sudden upheaval, and of those making answers to the inquiry ten or more were members of the teaching force there fifteen years ago and as many as four of these so long as thirty years ago. While in nowise conclusive, yet the practice of this engineering college and the opinion of these teachers can hardly be set aside lightly, especially in view of the fact that this practice conforms to that of most of those larger engineering colleges of high grade which maintain separate courses. It is quite fair then to say that the practice of early specialization in engineering courses is based upon and is the result of experience.

The present writer was much interested in the statement once made him by a member of the engineering faculty of a large university giving both the A.B. and the engineering degrees, that some disadvantage resulted because the four professors of Greek failed to appreciate the necessity for more than a single professor of civil engineering. These men were very honest but they were not in position to take a proper view of the matter. Not losing sight of the lesson of this incident, which shall we accept as the safer guide, the experience of those who have successfully tried early specialization or the doubts of those who have been through force of circumstances less intimately connected with its workings?

DISCUSSION.

PROFESSOR WHITED.—Professor Whited said it had been his duty and pleasure during a number of years to have something to do with breaking in the graduates in the engineering colleges in practical engineering work. He said he had had graduates under his charge from almost all the institutions, and he said he had found very little difference, the difference depending more upon the men than upon the institution. He said that, in his opinion, the institutions are all good, but that some of the men are good, and some not so good, and one of the first ideas that must be driven out of their heads is that they are engineers. The first work they may be trusted with in the drawing room is tracing, and infinite pains and care must be taken to get anything out of them. They must begin at the beginning. The things in which they are most often deficient are in the fundamental principles. When one finds young men who have designed steam-engines and who have not a thorough understanding of the principle of impact there is something wrong with their education. Some of them know a large number of formulas when they get through college and forget them very soon afterward. The speaker thought it not necessary or desirable to compel students to learn too many formulas; that in practical work thousands of dollars and lives depend on their being just right, and the practising engineer hardly ever risks his memory for a formula or a physical constant. He refers to tables and he is then sure he is right.

As to differentiation, the speaker said there was no branch of engineering but involves more or less of other branches. The civil engineer must handle machinery, and he has to handle metallurgical problems and chemical problems. Hardly any branch of practical life but involves more or less knowledge of chemistry. A knowledge of the elementary principles of the law of contracts is very valuable, and a great many other subjects that might be mentioned, but the student must, first of all, have a good, broad knowledge of fundamental principles of all branches of engineering. He never knows what he is going to meet in actual work, and if he knows the principles he is all right.

As to advanced studies, Professor Whited said he agreed with Professor Marburg, that the place for them is in the advanced courses. The student should understand that when he goes into practice he will have ample time to make special studies in special lines, and, as Professor Marburg has said, a man's opportunities or his circumstances might drive him into diverse lines. A few years ago electricity was very little taught, but how important it is to-day. The same may be said of very many other branches of knowledge.

Professor Emory.—Professor Emory said he supposed there were fifty different degrees, but he doubted if there were fifty different standards of engineering education. He thought if we could get together on the degree business we could eliminate a good deal of the discussion.

Professor Flather.—Professor Flather said the degree of sugar engineer had been left out of the discussion.

Professor Nagle.—Professor Nagle said he thought the question had been discussed pretty thoroughly on both sides. He did not feel exactly as did Professor Raymond, as a voice crying in the wilderness, but that of course every question has two sides. He said he was glad to see his position endorsed by a number of the gentlemen.

Professor Allen.—Professor Allen said he did not think it would have been quite dignified for him to have added to his paper the thought that was in his mind, that it would not be wise to follow the voice crying in the wilderness "Whatever is, is wrong."

Professor Brydone-Jack.—Professor Brydone-Jack said, on the subject of differentiation of courses, there is a tendency to go too much into specialization, thus rushing the student into detail work before the elementary principles have been thoroughly mastered. He thought this was shown by the experience of graduates when they enter upon practical work.

He said that he could appreciate the standpoint of the schools, and he could also appreciate the standpoint of the employers, because he had had the pleasure of employing technical graduates, and he had found always that the first thing necessary to do was to get out of their heads that they knew everything. After that it was possible to get good results.

The speaker said he would like to emphasize the fact that the engineering student, no matter what branch he pursues, should have a thorough mastery of the elementary principles, on which the foundation of all engineering knowledge is laid, and in his opinion there was not time in a four years' course to specialize the work. If the elementary principles are studied, and are illustrated by a certain amount of elementary laboratory work in four years, it is doing well, with the average student; but it was impossible to make finished engineers in four years. When he heard of a college which claims that finished engineers are made in that time it made him think of one or two so-called colleges which sell diplomas for the money there is in it, regardless of the knowledge or ability of those receiving them.

Professor Brydone-Jack said he had been very much interested in listening to the accounts of the laboratory courses, and he thought that there may be a little tendency to specialize also in the laboratory courses in this country. He was of the opinion that such courses should be given for the purpose of illustrating the lectures rather than to devote the whole time to laboratory work. So the speaker suggested that the rudimentary principles should be ground into the student in order to allow him to proceed with the practical work. He may learn in college things about the practical work which he will have to drop in actual practice, because every company has a system of its own which he must become acquainted with, and, while he is learning this, he should also have the faculty of learning how to apply the principles he has already learned in college. A student must study after graduation as well as before, and he must realize that after graduation he only enters the freshman year in the study of practical work.

At New Brunswick the speaker said they were reorganizing, to a certain extent, the engineering course. That it is in its infancy there, and the aim is to give a course which will fit a man to go ahead with his life work, giving the first principles thoroughly so that he will be better equipped than many others who have, perhaps, gone a little farther, but who are still handicapped by not knowing how to apply the things they have already learned.

Professor Waldo.—The speaker said it was a little embarrassing to have it said that the product of the engineering schools is good for nothing and that our boys, when they come into these practical places, have really learned nothing, or must come as babes to their work. He presumed there was one aspect in which this is true, and another aspect in which it is not true, and the latter is proven by the demands that are made for the graduates. Professor Waldo said he presumed that every school which is represented at the meeting has had demands for its graduates four or five times over, and that if the young men who graduate from the technical schools are not better than men not so graduated, how is it that they are in such demand? One thing that impressed the speaker was the fact that every man in debating the subject was speaking of the equipment of his own institution and the kind of course that is being pursued there. He inquired whether every institution gives shop work to all of its men; whether every institution asked that the chemists who are to do practical work shall go through the shops. He thought it was apparent that there were inconsistencies all along the line, and that a decided result had not been reached.

Discussion by some member whose name was not ascertained: "I am glad to hear Professor Waldo refer to the matter of the ignorance of our students when they take up practical work. It would have seemed unfortunate if that statement had gone unchallenged. It does not seem possible that they have to unlearn much, but rather that they have to go on learning. We do not expect to turn out finished products in the time at our disposal, but I believe a man who has had this training will be able to take up the work, and has taken up the work, and is doing a work which would not be possible without that training."

Professor Nagle.—Professor Nagle said he thought Mr. Whited's remark was misunderstood. The speaker said he himself thought the student when he begins his practical work must eliminate from his mind the thought that he knows it all.

Professor Johnson.—Professor Johnson asked why, if it is admitted that the graduate is not a finished product, he is led to think that he is a finished product by being presented with a specialized degree?

Professor Marvin.—Professor Marvin said that it is largely the fault of the young man. He goes to college for four years and lives a life limited by his study and his environment, and, if he is bright, gets the admiration and applause of his fellow but less capable students. On graduation, he naturally thinks that he knows more than he does and is worth more than he is. His real lack of knowledge and experience and the daring of youth lead him into undertaking things which he can not do, but through which he gets his further training.

The young man that goes out into practical service during his college course, spending his vacations at work, or taking a year off, has little trouble after finally leaving school in fitting in. In rare cases the egotism of a man makes continued trouble; but in most cases it is only the rubbing off of a natural greenness and rawness which quickly disappear, and which should not be charged against the school. Teachers, however, by constant preaching of the doctrines that the best growth comes by starting in the lowest positions, that continuous growth is necessary, and that one becomes an engineer only through experience in life as well as with materials and nature's laws, can largely influence the ideas of life and work which graduates should have.

REPORT OF THE COMMITTEE ON STATISTICS OF ENGINEERING EDUCATION.

BY WM. T. MAGRUDER, CHAIRMAN.

We would remind the members present that, at the New York meeting (1900), a "standing committee on statistics of engineering education" was appointed, and that they made a preliminary report at the Buffalo meeting (1901), which will be found on page 330 of Vol. IX. of the Proceedings of the Society. At the last meeting of the Society it was suggested that statistics might be gathered on some eleven different subjects which it was thought would be of much interest and of some value to the members. Blanks were prepared covering most of these subjects and sent to the members of the committee in February. The committee was of the opinion that the proposed blanks would require more time to fill out correctly than might be expected of college professors at any one time. Consequently, only three blanks were sent out this year for statistics which it was thought that every college had at easy command, and which its registrar could immediately produce on demand. The committee is pleased to report that there seem to have been but few misunderstandings, so far as the members have heard, as to what was desired, and the chief cause of error, after arithmetical ones, has been to differentiate the Bachelor of Science degree in general science from the Bachelor degrees in engineering and *vice versa*. The question has arisen several times as to whether short-course students should be counted as of collegiate grade or as preparatory students. Courses in architecture, as distinguished from courses in art, have been included in all known cases under engineering. Some confusion has arisen and some mistakes may have been made concerning the courses leading to degrees in chemical engineering and engineering chemistry as distinguished from courses which are purely academic or scientific.

As suggested by Professor Merriman, the committee sent out with the blanks certain definitions of the sense in which the terms were used. These seem to have met with general favor, and at least have served their purpose, so far as they have gone, of informing the reader of the sense in which the committee used certain words. The committee is aware that, as has been well said by Professor H. S. S. Smith, of Princeton University, that "Educational institutions, like books, have not been made and named for purposes of classification." Nevertheless, although universities are very generally divided into colleges, quite a number of institutions of approximately the same grade are called colleges, and are divided into schools. In fact some universities have both colleges and schools. It would seem desirable that the members of this Society use their influence in their respective college and university faculties (or shall we say "school faculties") to standardize both engineering and educational terms, so that there shall be the least possible confusion in their use.

The idea in formulating the blanks which were sent out was to save others the necessity for doing anything more than putting the proper figures in the proper places. It is hoped that the work of the committee will lead to more of our colleges keeping and publishing statistics concerning their own work and numbers. The committee believes that, unless the members of the Society have taken the trouble to tabulate the statistics for their own institution on such things as the number of students in the different courses from year to year, the number of degrees given, the number of students per instructor, the relative expenditures and the like, that they will be surprised to see the results of their inquiries.

The committee would suggest that the members use it as a clearing-house for the dissemination of statistical information obtained or gathered by them in order that the committee may be able on inquiry to state whether statistics of a particular kind are already accessible or not—with a possible saving of effort to statisticians and to college officers.

The committee believes that the work of this society can be made to have its influence in coöperation with or improvement of the statistical work of the Bureau of Education concerning engineering education.

It is of the unanimous opinion that students pursuing merely courses in shop-work and mechanic arts should not be included in the list of, and counted as, students pursuing courses in mechanical engineering.

The committee tried to secure statistics of the enrollments for the year 1901–1902, and purposely put it off until after the beginning of the last term of the college year. Replies have not yet (October 10, 1902) been received from all the institutions, and a number have neglected to return the blanks, or to make any acknowledgment of the repeated requests which have been made, even when a stamped and addressed envelope was enclosed for a reply.

The committee finds that very few of the colleges are opposed to the gathering and the publication of statistics concerning them and their work.

In conclusion, the committee would recommend that it is the sense of this meeting that the authorities of the various engineering colleges be urged to publish fuller and more complete statistics each year concerning their enrollments, the distribution of the students by courses and by years, and also a list of the different degrees conferred.

WM. T. MAGRUDER,
ROBERT FLETCHER,
HENRY S. JACOBY,
LOUIS E. REBER,
ARTHUR N. TALBOT,
HARRY W. TYLER,
Committee.

DEFINITIONS OF TERMS USED.

Actual Hour. A period of time of not less than fifty minutes nor more than sixty by the clock. If other lengths of periods are intended, note same and their lengths, or else convert them into hours of fifty-five minutes by the clock.

Lecture. A discourse by the instructor at which the student is a listener and may take notes.

Recitation. A written or oral examination on an assigned subject.

Quiz. A dialogue between the instructor and student consisting of questions and answers. (The time used in writing up lecture notes or in preparing for recitations and quizzes is not to be included under these heads.)

Drawing, Shop, Laboratory, Field-work. Practical manual exercises conducted by these means. (The amount of time required by the student to be used in the building or on the land of the institution is desired, and not the time spent in outside preparation or in writing up notes.)

Course. A series of subjects grouped together on which instruction and practice is given and leading to some definite end and usually to a degree.

Subject. A branch of knowledge upon which instruction is given.

College Year. The time from the opening of the session in the fall to commencement day.

Supplementary Term. The time devoted to instruction and practice between commencement day and the opening of the next college year.

University. An institution of learning of the highest grade in which instruction is given on several different branches of knowledge required by the several professions or occupations other than the trades, and consisting of several colleges, or schools.

College. A division of a university or an institution in which instruction is given on the branches of knowledge required by a profession or occupation other than the trades, *e. g.,* college of engineering, law, theology, commerce, arts and science, institute of technology, school of applied science.

Institute. Synonymous with college, if of collegiate grade.

Department. A division of a college in which instruction is given on a set of related subjects required by some branch of a profession or occupation other than the trades, *e. g.,* the department of mathematics, drawing, French or civil engineering.

School. In certain parts of the country, "school" is synonymous with department, and "department" is synonymous with college, several of which form a university. The division "college" is entirely omitted, as here defined.

In some institutions, "school" is synonymous with "college" as here defined.

NOTES ON TABLE I.

(a) Alabama Polytechnic Institute. Only junior and senior engineering students are included. All freshmen and sophomore students are included in the academic college.

(b) University of Illinois. These 67 students are in the "Library School."

(c) University of California. These 59 students are in the "College of Commerce."

(d) Syracuse University. The 677 students in music include those in art.

(e) Special students.

(f) Kansas Agricultural College. The 164 engineering students do not include those of the first year.

(g) University of Missouri. Under academic are included 178 normal students of both sexes.

(h) Syracuse University. Collegiate scientific students are included under collegiate academic students.

(i) Rensselaer Polytechnic Institute. The 5 scientific students are in short-courses, and are not preparatory students.

(j) University of Michigan, *et al.* Scientific students are included under academic.

(k) University of North Dakota. These 20 students are in a course preparatory to law.

(l) State University of Iowa. These 94 students are unclassified.

(m) Kansas Agricultural College. These 685 students are first year unclassified students.

(n) Cornell University. These 44 students are in "forestry."

(p) Columbia University. Of these 927 students, 900 are in "courses for teachers" and 27 are in "other courses."

(q) University of Pennsylvania. These 14 students are in "hygiene."

(r) A. and M. College of Texas. These 20 students are pursuing "elective" courses.

(s) Washington Agricultural College. Of these 79 students, 15 are pursuing the "artisan course," and 64 are pursuing the "business course."

(t) Dartmouth College. The figures given include only the students in "The Thayer School of Civil Engineering connected with Dartmouth College."

NOTES ON TABLE II.

(a) Alabama Polytechnic Institute. Only junior and senior engineering students are included. All freshmen and sophomore students are included in the academic college.

(b) University of California. The 14 C. E. specials include 12 "specials" and 2 "limited." The 25 M. E. specials include 15 "specials" and 10 "limited." The 48 E. M. specials include 37 "specials" and 11 "limited" students.

(c) University of Kansas. "Preparatory students are really freshmen with conditions, making them up in the 'School of Arts' and are entitled 'unclassed.'"

(d) Kansas Agricultural College. These 164 students are exclusive of the freshmen.

(e) Tulane University. The 22 specials are in "sugar engineering."

(f) Michigan College of Mines. The course is of three "long" years of four terms each.

(g) Montana College of A. & M. First and second year engineering students are included under specials.

(i) Dartmouth College. The figures given include only the students in "The Thayer School of Civil Engineering connected with Dartmouth College."

(m) West Virginia University. Four years in preparatory course.

(n) Georgia School of Technology. The 115 specials are in "textile engineering."

(o) University of Illinois. These 66 students in "architecture" include $4 + 16 + 8 + 8 + 8 = 44$ collegiate + 4 post-graduate students in "architecture," and $0 + 9 + 4 + 2 + 3 = 18$ undergraduates in "architectural engineering."

(p) Rose Polytechnic Institute. These 7 students are in the course of "civil engineering in architecture" and not "architecture."

(q) University of Michigan. This one student is in "marine engineering" and not "naval architecture."

(r) University of Minnesota. Of these 27 special students, 7 are in the five-year course in "science and technology," and 20 are "unclassified."

(s) University of Missouri. These $176 + 7 = 183$ "special" students, are unclassified and are enrolled at the Missouri School of Mines and Metallurgy at Rolla, Mo.

(t) Cornell University. The Sibley College undergraduates are included as "specials" under E. E., M. E. and N. A. Of the 633 students in M. E., 10 are in "Railway Mechanical Engineering."

(u) Leland Stanford Jr. University. Of the 53 C. E., 45 E. E., 32 M. E. and 89 E. M. students, 49, 39, 21 and 81, respectively, are in regular four year courses, and are "unclassified." The balance of 4, 6, 11 and 4 are "specials."

(v) University of Wisconsin. Of the 218 specials, 181 are regular unclassified freshmen. The 9 students in "general engineering" are also tabulated as special students.

(w) Unclassified first year students are tabulated as "Specials."

(x) Students in E. E. are included under M. E.

(y) Students in metallurgy are included under mining.

(z) Unclassified students are counted as specials.

TABLE I.

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901-2.

	INSTITUTION.	Engineering.						Academic.					
		Prep.	Short Course.	Collegiate.		Post Grad.	Total.	Prep.		Collegiate.		Post Grad.	
		M	M	M	F	M		M	F	M	F	M	F
1	Alabama Polytechnic Inst., Auburn, Ala.			70		4	a 74	58		204	5	6	4
2	Howard College, East Lake, Ala.												
3	Univ. of Alabama, University, Ala.												
4	University of Arizona, Tuscon, Ariz.		4	36		2	42	26	70				2
5	Univ. of Arkansas, Fayetteville, Ark.												
6	Univ. of Cal., Berkeley, Cal.			529		9	538			364	872	78	92
7	Throop Polytechnic Inst., Pasadena, Cal.												
8	Stanford Univ., Stanford University, Cal.			215		4	219			590		64	
9	Univ. of Colorado, Boulder, Colo.			102	1		103			117	146	16	6
10	Colorado Agr. Col., Ft. Collins, Colo.			109		4	113						
11	State School of Mines, Golden, Colo.			243	1		244						
12	Yale Univ., New Haven, Conn.												
13	Conn. Agr. Col., Storrs, Conn.												
14	State Col. for Colored, Dover, Del.												
15	Delaware College, Newark, Del.			59			59			11		1	
16	Catholic Univ. of Am., Washington, D. C.												
17	Gallaudet Col., Washington, D. C.												
18	Florida Agr. Col., Lake City, Fla.												
19	Univ. of Georgia, Athens, Ga.			30			30			130			
20	Georgia School of Tech., Atlanta, Ga.		25	407			432						
21	Univ. of Idaho, Moscow, Idaho												
22	Univ. of Illinois, Urbana, Ill.			472	3	23	498	177	90	172	209	11	7
23	Armour Inst. of Tech., Chicago, Ill.	330		351			681	10	28				
24	Purdue Univ., Lafayette, Ind.			802		25	827						
25	Univ. of Notre Dame, Notre Dame, Ind.												
26	Earlham Col., Richmond, Ind.												
27	Rose Poly. Inst., Terre Haute, Ind.			164		2	166						
28	Iowa Col. of A. & M. Arts, Ames, Iowa	136		418			554						
29	State Univ. of Iowa, Iowa City, Iowa			54		3	57			195	187	58	19
30	Cornell Col., Mt. Vernon, Iowa		12	45			57	128	130	89	134	3	1
31	Univ. of Kansas, Lawrence, Kans.	36		165	1	4	206			294	325	36	29
32	Kansas Agr. Col., Manhattan, Kans.		67	96		1	f 164						
33	Albertus Magnus Col., Wichita, Kans.												
34	A. & M. Col. of Ky., Lexington, Ky.			182		1	183	95	15	61	28	2	
35	Louisiana St. Univ., Baton Rouge, La.												
36	Tulane Univ., New Orleans, La.			148		2	150		154	93	142	3	30
37	Univ. of Maine, Orono, Maine.			209		2	211			13	6		
38	St. John's Col., Annapolis, Md.												
39	Maryland Agr. Col., Col. Park, Md.												
40	Mass. Inst. of Tech., Boston, Mass.			1335		9	1344						
41	Harvard Univ., Cambridge, Mass.			283			283			1983		312	
42	Tufts College, Tufts College, Mass.	7		87			94			84	100	6	1
43	Worcester Poly Inst., Worcester, Mass.												
44	Michigan A. Col., Agr. College, Mich.	72		177			249						
45	Univ. of Michigan, Ann Arbor, Mich.			484		5	489		j	659	634	71	36
46	Michigan Col. of Mines, Houghton, Mich.			177		5	182						
47	Univ. of Minnesota, Minneapolis, Minn.			440	1		441			544	635	127	49
48	Mississippi A. & M. Col., Agr. Col., Miss.												
49	Univ. of Mississippi, Univ, Miss.			27			27			73	19	13	4
50	Univ. of Missouri, Columbia and Rolla, Mo.			353		13	366	j	g	323	168	23	16
51	Washington Univ., St. Louis, Mo.												
52	Montana Col. of A. & M. Arts, Bozeman			24			24						
53	Univ. of Montana, Missoula, Mont.												
54	Univ. of Nebraska, Lincoln, Neb.	72		162			234	45	44	328	372	35	41
55	Nevada St. Univ., Reno, Nev.												
56	Col. of A. & M. Arts, Durham, N. H.			52			52						
57	Thayer School of Civil Engineering*			t 19		13	32						
58	St. Anselm's Col., Manchester, N. H.												
59	Stevens Inst. of Tech., Hoboken, N. J.	229		269			498						
60	Rutgers College, New Brunswick, N. J.												
61	Princeton Univ., Princeton, N. J.			157		6	163			760		116	j
62	Col. of A. & M. Arts, Mesilla Park, N. M.	20		8			28	100					
63	New Mexico School of Mines, Socorro, N. M.												
64	Polytechnic Institute, Brooklyn, N. Y.			83		3	86	519		9			
65	Cornell Univ., Ithaca, N. Y.			1056		26	1082			831		147	
66	Columbia Univ., New York, N. Y.			572		11	583			492	339	301	146
67	Manhattan College, New York, N. Y.												
68	New York Univ., New York, N. Y.			96		8	104			240			
69	Clarkson School of Tech., Potsdam, N. Y.			64			64						

* Connected with Dartmouth College, Hanover, N. H.

TABLE I.—*Continued.*

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901-2.

	INSTITUTION.	Engineering.						Academic.					
		Prep.	Short Course.	Collegiate.		Post Grad.	Total.	Prep.		Collegiate.		Post Grad.	
		M	M	M	F	M		M	F	M	F	M	F
70	Union College, Schenectady, N. Y.			75			75		34	91			
71	Syracuse Univ , Syracuse, N. Y.			103			103			h 797		20	9
72	Rensselaer Poly. Inst., Troy, N. Y.		4	241			245						
73	A. & M. Col. for Col'd Race, Greensboro, N. C.												
74	N. C. Col. of A. & M. Arts, W. Raleigh, N. C.												
75	N. Dakota Agr. Col., Agr. Col., N. Dakota.												
76	Univ. of North Dakota, University, N. D.	10		17			27	89	34	43	19	2	3
77	Ohio Normal Univ., Ada, Ohio			111	4	27	142	212	90	96	20	30	5
78	Univ. of Cincinnati, Cincinnati, Ohio												
79	Case School of Applied Sci., Cleveland, O.			354			354						
80	Ohio State University, Columbus, Ohio		53	529	3		585			j 403		j 47	
81	Oklahoma A. & M. Col., Stillwater, Okla.												
82	Oregon Agr. Col., Corvallis, Oregon.												
83	Univ. of Oregon, Eugene, Oregon.*												
84	Western Univ. of Pa., Allegheny, Pa.												
85	Penna. Military Col., Chester, Pa.												
86	Lafayette Col., Easton, Pa.			124			124			231		16	
87	Haverford Col., Haverford, Pa.			29			29			72		3	
88	Allegheny Col., Meadville, Pa.												
89	Univ. of Penna., Philadelphia, Pa.		19	327			346			j 461		j 179	
90	Lehigh Univ., South Bethlehem, Pa.			482		4	486			31		3	
91	Penna. State Col., State College, Pa.		2	339	1	3	345			5	1		
92	Swarthmore Col., Swarthmore, Pa.												
93	College of Agr. & Mech. Arts, Kingston, R. I.			17		1	18	44	15	7	4		2
94	Brown Univ., Providence, R. I.			79			79			569	176	56	38
95	Clemson Agr. Col., Clemson Col., S. C.												
96	South Carolina Col., Columbia, S. C.												
97	S. Dakota Agr. Col., Brookings, S. D.												
98	State School of Mines, Rapid City, S. Dak.												
99	Univ. of Tennessee, Knoxville, Tenn.												
100	Vanderbilt Univ., Nashville, Tenn.			45			45				j 223		
101	University of the South, Sewanee, Tenn.												
102	University of Texas, Austin, Tex.												
103	A. & M. College of Texas, Col. Station, Tex.			227		1	228						
104	Agr. College of Utah, Logan, Utah												
105	University of Vermont, Burlington, Vt.			83			83			53	25	1	
106	Norwich University, Northfield, Vt.												
107	Virginia A. & M. Col., Blacksburg, Va.			300		21	321						
108	Univ. of Virginia, Charlottesville, Va.												
109	Washington & Lee Univ., Lexington, Va.			26			26			153		4	
110	Washington Agr. Col., Pullman, Wash.			70			70	208		39			
111	Univ. of Washington, Seattle, Wash.												
112	West Virginia Univ., Morgantown, W. Va.	60		52			112	183	39	83	36	23	3
113	Univ. of Wisconsin, Madison, Wis.			506		7	513			612	454	81	34
114	Univ. of Wyoming, Laramie, Wyo.	22		22			44	17	20	10	10	3	1
115	Univ. of Sydney, Sydney, Australia			102			102			181	63	14	
116	McGill University, Montreal, Canada	25		223		3	251			162	118	3	8
117	School of Practical Science, Toronto, Can.		1	269		14	284						
118	University College, Sheffield, Eng.		1	127		2	130						
Totals.	Males and Females in U. S., unclassified							208		3121	223	437	
	Males and Females in U. S., classified.	994	186	14989	15	249	16433	1703	729	9294	5066	1460	578
	Males and Females, classified	1019	188	15710	15	268	17200	1703	729	9637	5247	1477	586
	Males and Females, unclassified.							208		3121	223	437	

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—Numbers at the left carry forward any given institution through the tables.

NOTE 3.—The references are to the notes given on page 236.

TABLE Ia.

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901–2.

	Acad.	Scientific.							Summer Cou.			Teach. C.			Normal.							Agric.			
	Total.	Prep.		Collegiate.		Post Grad.		Total.	Collegiate.		Total.	Collegiate.		Total.	Prep.		Collegiate.		Post Grad.		Total.	Prep.		Short Course.	
		M	F	M	F	M	F		M	F		M	F		M	F	M	F	M	F		M	F	M	F
1	277			53		6		59																	
2																									
3																									
4	98	64	1					65																	
5																									
6	1406			258	107	26	20	411	799		799													37	
7																									
8	654			196		22		218																	
9	285																								
10																									
11																									
12																									
13																									
14																									
15	12			82		5		87																	
16																									
17																									
18																									
19	130			125				125																	
20																									
21																									
22	666			108	28	28	1	165	132	72	204													138	
23	38																								
24				58	48	5	10	121																	
25																									
26																									
27																									
28		33		89		4		126														17		400	
29	459			75	23	25	4	127	50	85	135														
30	485			61	49			110																	
31	684																								
32				77	30	3	6	116																190	1
33																									
34	201			35	23	7	3	68									26	5			81				
35																									
36	422																								
37	19			51	5	3		59																	
38																									
39																									
40				64				64																	
41	2295			266				266																	
42	191			20	3			23																	
43																									
44																								94	
45	1400								287	129	416														
46																									
47	1355																								
48																									
49	109			44	6	9		59																	
50	530																							55	2
51																									
52		45	45	9	9	1	1	110														22		3	
53																									
54	865	20	4	100	38	24	8	194														118		12	
55																									
56																								19	
57																									
58																									
59																									
60																									
61	876			315		j		315																	
62	100	75				1		76														2		2	
63																									
64	528																								
65	978								501		501													96	
66	1278			43		52	9	104	153	426	579	118	516	634											
67																									
68	240																								
69																									

TABLE Ia.—*Continued.*

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901–2.

	Acad.	Scientific.							Summer Cou.			Teach. C.			Normal.							Agric.			
	Total.	Prep.		Collegiate.		Post Grad.		Total.	Collegiate.		Total.	Collegiate.		Total.	Prep.		Collegiate.		Post Grad.		Total.	Prep.		Short Course.	
		M	F	M	F	M	F		M	F		M	F		M	F	M	F	M	F		M	F	M	F
70	91			29				29																	
71	h826					4	1	5																	
72		i5						5																	
73																									
74																									
75																									
76	j190														10	98	6	18			132				
77	453	181	37	70	18	64	16	386							465	399	56	23	11	10	964				
78																									
79																									
80	450																							88	
81																									
82																									
83																									
84																									
85																									
86	247			48		2		50																	
87	75			15				15																	
88																									
89	640																								
90	34			34				34																	
91	6	39		54	5	1		99																43	
92																									
93	72			12	12			24																87	2
94	839			2				2																	
95																									
96																									
97																									
98																									
99																									
100	223																								
101																									
102																									
103																								9	
104																									
105	79			57	39			96																48	2
106																									
107				112		7		119																	
108																									
109	157																								
110	247			21				21	139		139											72		59	
111																									
112	j367																							36	
113	j1181																							425	
114	61															8		30			38				
115	258			11	1			12																	
116	291																156				156				
117		1		8		2		6																	
118																									
Totals.				217		22			1439													72		366	
	22819	462	87	2316	443	277	79	3903	622	712	2773	118	516	634	475	505	88	76	11	10	1165	159		1425	7
	23368	463	87	2330	444	279	79	3921	622	712	2773	118	516	634	475	505	244	76	11	10	1321	159		1425	7
				217		22			1439													72		366	

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—Numbers at the left carry forward institutions numbered on pp. 238, 239.

NOTE 3.—The references are to the notes given on page 236.

TABLE I*b*.

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901-2.

	Agriculture.					Domestic Sci.					Music.					Art.							Law.				
	Collegiate.		Post Grad.		Total.	Prep.	Short Course.	Collegiate.	Post Grad.	Total.	Collegiate.		Post Grad.		Total.	Prep.		Collegiate.		Post Grad.		Total.	Collegiate.		Post Grad.		Total.
	M	F	M	F		F	F	F	F		M	F	M	F		M	F	M	F	M	F		M	F	M	F	
1																											
2																											
3																											
4						10				10																	
5																											
6	52	9	3	0	101													82	104			186	101	5			106
7																											
8																		19				19	171		14		185
9																							72	1			73
10	19		1		20			47	1	48																	
11																											
12																											
13																											
14																											
15	6				6																						
16																											
17																											
18																											
19	2				2																						
20																											
21																											
22	65	1	4		208		9	14		23	8	52			60			3	12			15	112	2			114
23																											
24	119		1		120																7	7					
25																											
26																											
27																											
28	204		2		623	23		88	4	115	27				27												
29																							215				215
30											20	130			150	11	30					41					
31											7	86			93								172	1			173
32	74		11		276		41	103	11	155																	
33																											
34	6				6																						
35																											
36																			84		9	93	78				78
37	16				16																		47				47
38																											
39																											
40																											
41	32				32																		628				628
42																											
43																											
44	192		7		293			158		158																	
45																							846	5	3		854
46																											
47	494	125			619																		475	5	23	1	504
48																											
49																							53				53
50	2				59			26		26													139	2	2		143
51											Pr.	Coll.															
52					25	4	9			13	4 34	2 23			63												
53																											
54					130	21				21	36	258			294			7	58			65	163	2			165
55																											
56	27				46																						
57																											
58																											
59																											
60																											
61																											
62	1				5	4		13		17																	
63																											
64																											
65	92		14		202																		198				198
66																							440				440
67																											
68																							587		15	70	672
69								17		17																	

TABLE 1b.—*Continued.*

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901-2.

	Agriculture.					Domestic Sci.					Music.					Art.							Law.				
	Collegiate.		Post Grad.		Total.	Prep.	Short Course.	Collegiate.	Post Grad.	Total.	Collegiate.		Post Grad.		Total.	Prep.		Collegiate.		Post Grad.		Total.	Collegiate.		Post Grad.		Total.
	M	F	M	F		F	F	F	F		M	F	M	F		M	F	M	F	M	F		M	F	M	F	
70																							120		2		122
71											d665		2	10	677								143				143
72																											
73																											
74																											
75																											
76											Prep.	Coll.											k20				20
77											74 289	6 21	6	14	410			362	15	2		379	127	1	12		140
78																											
79																											
80	64		2		154		6	38		44													186		2		188
81																											
82																											
83																											
84																											
85																											
86																											
87																											
88																											
89											12	22			34			4	3			7	380	6			386
90																											
91	13				56																						
92																											
93	1		1		41																						
94																											
95																											
96																											
97																											
98																											
99																											
100																							46				46
101																											
102																											
103	208		2		219																						
104																											
105	37				87																						
106																											
107	33				33																						
108																											
109																							54				54
110	6				137						63				63			10				10					
111																											
112					36						17	74			91	100	27	12	17			156	110				110
113	16	2	5		448						73 Pr.	47 145	7		272								258	2			260
114	1				1																						
115																							32				82
116																							47				47
117																											
118																											
Total.	98		14								755		7					29					369		14		
	1684	137	39		4001	62	65	504	16	647	574	866	8	24	2234	111	57	470	293	2	16	978	5572	32	59	71	6117
	1684	137	39		4001	62	65	504	16	647	574	866	8	24	2234	111	57	470	293	2	16	978	5651	32	59	71	6196
	98		14								755		7					29					369		14		

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—Numbers at the left carry forward institutions numbered on pp. 238, 239.

NOTE 3.—The references are to the notes on page 236.

TABLE Ic.

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901-2.

	Dentistry.				Medicine.				Vet. Medicine.						Pharmacy.						Theology, etc.					Gross Totals.	Names Counted Twice.	Net Totals.
	Collegiate.		Post Grad.	Total.	Collegiate.		Post Grad.	Total.	Short Course.	Collegiate.		Post Grad.		Total.	Short Course.	Collegiate.		Post Grad.		Total.	Collegiate.		Post Grad.		Total.			
	M	F	M		M	F	M		M, F	M	F	M	F		M	M	F	M	F		M	F	M	F				
1																24				24						434		434
2																												
3																												
4																										215		215
5																												
6	133	3		136	131	19	12	162								70	17			87	54	8	2	0	c 59	3991	190	3801
7																												
8																										1295		1295
9					57	6		63																		524		524
10										4				4												185		185
11																										244		244
12																												
13																												
14																												
15																										114		114
16																												
17																												
18																												
19																										287		287
20																										432		432
21																					Library Sch.							
22	129	5		134	658	50		708								153	1			154	4	63			b 67	3016	84	2932
23																					Spec.					719		719
24																91				91	1	12			e 13	1179		1179
25																												
26																												
27																										166		166
28										45				45												1490		1490
29	150	8	1	159	289	38		327								57	1			58	29	44	1	20	1 94	1631	119	1512
30																										843	117	726
31					89			89								80	7			87						1282	49	1233
32																					498	187	1st Yr.		m685	1396		1396
33																												
34																										489		489
35																												
36					361		37	398								25	1			26						1167		1167
37																21				21	21	Spec.			e 21	394		394
38																												
39																												
40																										1408		1408
41	105			105	506			506													87				87	4152		4152
42	207	8		215	265	57		322													15				15	860		860
43																												
44																										700		700
45	196	7		203	520	45	8	573								57	2	9		68						4003	294	3709
46																										182		182
47	105			105	362	20	1	383								49	12	1		62						3469		3469
48																												
49																										248		248
50					86	2		88																		1212		1212
51																												
52																										235		235
53																												
54																										1968		1968
55																												
56																										98		98
57																										32		t 32
58																												
59																										498		498
60																												
61																										1354		1354
62																										226		226
63																												
64																										614		614
65					433			433	8	51		2		61							44 Forestry				n 44	3499	49	3450
66					809			809													927				p927	5354	220	5134
67																												
68					306			306																		1322		1322
69																										81		81

TABLE Ic.—*Continued.*

Enrollments by Colleges of the Educational Institutions of the United States, having Courses in Engineering for the Year 1901–2.

	Dentistry.				Medicine.				Vet. Medicine.						Pharmacy.						Theology, etc.					Gross Totals.	Names Counted Twice.	Net Totals.
	Collegiate.		Post Grad.	Total.	Collegiate.		Post Grad.	Total.	Short Course.	Collegiate.		Post Grad.		Total.	Short Course.	Collegiate.		Post Grad.		Total.	Collegiate.		Post Grad.		Total.			
	M	F	M		M	F	M		M,F	M	F	M	F		M	M	F	M	F		M	F	M	F				
70					154			154								54				54						525		525
71					128			128																		1882	76	1806
72																										250		250
73																												
74																												
75																												
76																										369		369
77																108		86	2	196						3070		3070
78																												
79																										354		354
80										67				67	23	17				40						1528	12	1516
81																												
82																												
83																												
84																												
85																												
86							1	1																		422	3	419
87																					6	Specials			e6	125		125
88																												
89	365			365	542			542		78				78							14	Hyg'ne			q14	2412		2412
90																										554		554
91																										506		506
92																												
93																										155	2	153
94																										920		920
95																												
96																												
97																												
98																												
99																												
100	95			95	158			158								54				54	65				65	686		686
101																												
102																												
103																					20	Elective			r20	467		467
104																												
105					155			155																		500		500
106																												
107																										473		473
108																												
109																										237		237
110										5				5		31				31	15 Art.	64 Bus.			s79	802	58	744
111																												
112					15			15													84	Special			e84	971	216	755
113																32	3			35						2709		2709
114																										144		144
115	16			16	175	14		189								40		4		44						653		653
116					420			420																		1165		1165
117																										290		290
118																										130		130
Total.					433				8	123			2			31					941							
	1485	31	1	1517	5541	237	59	6270		127				260	23	892	44	96	2	1088	957	309	3	20	2230	73069	1489	71580
	1501	31	1	1533	6136	251	59	6879		127				260	23	932	44	100	2	1132	957	309	3	20	2230	75307	1489	73818
					433				8	123			2			31					941							

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—Numbers on the left carry forward institutions numbered on pp. 238, 239.

NOTE 3.—The references are to the notes given on page 236.

TABLE II.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	INSTITUTION.	Architecture.													Ceramics.					
		Short Course.		Collegiate.							Post Grad.			Grand Total.	Short Course.		Collegiate.			
		I	II	Sp.	I	II	III	IV	V	To.	I	II	III		I	II	Sp.	II	III	IV
1	Alabama Polytechnic Inst., Auburn, Ala.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	Howard College, East Lake, Ala.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	Univ. of Alabama, University, Ala.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	University of Arizona, Tuscon, Ariz.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	Univ. of Arkansas, Fayetteville, Ark.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	Univ. of Cal., Berkeley, Cal.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Throop Polytechnic Inst., Pasadena, Cal.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	Stanford Univ., Stanford University, Cal.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	Univ. of Colorado, Boulder, Colo.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	Colorado Agr. Col., Ft. Collins, Colo.	...	...	...	3	5	1	...	...	9	...	...	...	9	...	...	...	...	...	...
11	State School of Mines, Golden, Colo.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	Yale Univ., New Haven, Conn.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	Conn. Agr. Col., Storrs, Conn.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	State Col. for Colored, Dover, Del.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	Delaware College, Newark, Del.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16	Catholic Univ. of Am., Washington, D. C.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
17	Gallaudet Col., Washington, D. C.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18	Florida Agr. Col., Lake City, Fla.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19	Univ. of Georgia, Athens, Ga.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	Georgia School of Tech., Atlanta, Ga.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
21	Univ. of Idaho, Moscow, Idaho.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
22	Univ. of Illinois, Urbana, Ill.	...	...	4	25	12	10	11	...	62	4	...	o	66	...	...	...	...	...	...
23	Armour Inst. of Tech., Chicago, Ill.	...	...	19	6	2	...	...	...	27	...	...	...	27	...	...	...	...	...	...
24	Purdue Univ., Lafayette, Ind.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25	Univ. of Notre Dame, Notre Dame, Ind.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
26	Earlham Col., Richmond, Ind.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
27	Rose Poly. Inst., Terre Haute, Ind.	...	...	...	2	3	1	1	...	7	...	...	p	7	...	...	...	...	...	...
28	Iowa Col. of A. & M. Arts, Ames, Iowa.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29	State Univ. of Iowa, Iowa City, Iowa.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	Cornell Col., Mt. Vernon, Iowa.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	Univ. of Kansas, Lawrence, Kans.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
32	Kansas Agr. Col., Manhattan, Kans.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
33	Albertus Magnus Col., Wichita, Kans.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
34	A. & M. Col. of Ky., Lexington, Ky.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35	Louisiana St. Univ., Baton Rouge, La.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
36	Tulane Univ., New Orleans, La.	...	...	...	...	...	...	2	...	2	...	...	...	2	...	...	...	...	...	...
37	Univ. of Maine, Orono, Maine.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
38	St. John's Col., Annapolis, Md.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
39	Maryland Agr. Col., Col. Park, Md.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40	Mass. Inst. of Tech., Boston, Mass.	...	...	...	—	14	10	16	...	40	...	...	...	40	...	...	...	...	...	...
41	Harvard Univ., Cambridge, Mass.	...	...	10	5	7	3	4	...	29	...	...	...	29	...	...	...	...	...	...
42	Tufts College, Tufts College, Mass.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
43	Worcester Poly Inst., Worcester, Mass.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
44	Michigan A. Col., Agr. College, Mich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
45	Univ. of Michigan, Ann Arbor, Mich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
46	Michigan Col. of Mines, Houghton, Mich.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
47	Univ. of Minnesota, Mineapolis, Minn.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
48	Mississippi A. & M. Col., Agr. Coll., Miss.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
49	Univ. of Mississippi, Univ. Miss.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
50	Univ. of Missouri, Columbia and Rolla, Mo.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
51	Washington Univ., St. Louis, Mo.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
52	Montana Col. of A. & M. Arts, Bozeman.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
53	Univ. of Montana, Missoula, Mont.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
54	Univ. of Nebraska, Lincoln, Neb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
55	Nevada St. Univ., Reno, Nev.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
56	Col. of A. & M. Arts, Durham, N. H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
57	Thayer School of Civil Engineering*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
58	St. Anselm's Col., Manchester, N. H.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
59	Stevens Inst. of Tech., Hoboken, N. J.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
60	Rutgers College, New Brunswick, N. J.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
61	Princeton Univ., Princeton, N. J.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
62	Col. of A. & M. Arts, Mesilla Park, N. M.	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...
63	New Mexico School of Mines, Socorro, N. M.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
64	Polytechnic Institute, Brooklyn, N. Y.	...	...	1	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...
65	Cornell Univ., Ithaca, N. Y.	...	...	5	17	10	8	10	...	50	...	...	2	52	...	...	...	...	...	...
66	Columbia Univ., New York, N. Y.	...	...	12	29	16	13	15	...	85	...	1	...	86	...	...	...	...	...	...
67	Manhattan College, New York, N. Y.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
68	New York Univ., New York, N. Y.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
69	Clarkson School of Tech., Potsdam, N. Y.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Connected with Dartmouth College, Hanover, N. H.

TABLE II.—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the year 1901–1902.

	INSTITUTION.	Architecture.													Ceramics.					
		Short Course.		Collegiate.							Post Grad.			Grand Total.	Short Course.		Collegiate.			
		I	II	Sp.	I	II	III	IV	V	To.	I	II	III		I	II	Sp.	II	III	IV
70	Union College, Schenectady, N. Y.																			
71	Syracuse Univ., Syracuse, N. Y.																			
72	Rensselaer Poly. Inst., Troy, N. Y.																			
73	A. & M. Col. for Col'd. Race, Greensboro, N. C.																			
74	N. C. Col. of A. & M. Arts, W. Raleigh, N. C.																			
75	N. Dakota Agr. Col., Agr. Col., N. Dakota.																			
76	Univ. of North Dakota, University, N. D.																			
77	Ohio Normal Uni., Ada, Ohio			3						3	1			4						
78	Univ. of Cincinnati, Cincinnati, Ohio				1															
79	Case School of Applied Sci., Cleveland, O.				—	1		1		2				2						
80	Ohio State University, Columbus, Ohio				—	5	3			8				8	12	5	6	4	3	3
81	Oklahoma A. & M. Col., Stillwater, Okla.																			
82	Oregon Agr. Col., Corvallis, Oregon																			
83	Univ. of Oregon, Eugene, Oregon																			
84	Western Univ. of Pa., Allegheny, Pa.																			
85	Penna. Military Col., Chester, Pa.																			
86	Lafayette Col., Easton, Pa.																			
87	Haverford Col., Haverford, Pa.																			
88	Allegheny Col., Meadville, Pa.																			
89	Univ. of Penna., Philadelphia, Pa.	10	5	1	6	10	14	6	1	38				53						
90	Lehigh Univ., South Bethlehem, Pa.																			
91	Penna. State Col., State College, Pa.																			
92	Swarthmore Col., Swarthmore, Pa.																			
93	College of Agr. & Mech. Arts, Kingston, R. I.																			
94	Brown Univ., Providence, R. I.																			
95	Clemson Agr. Col., Clemson Col., S. C.																			
96	South Carolina Col., Columbia, S. C.																			
97	S. Dakota Agr. Col., Brookings, S. D.																			
98	State School of Mines, Rapid City, S. Dak.																			
99	Univ. of Tennessee, Knoxville, Tenn.																			
100	Vanderbilt Univ., Nashville, Tenn.																			
101	University of the South, Sewanee, Tenn.																			
102	University of Texas, Austin, Tex.																			
103	A. & M. College of Texas, Coll. Station, Tex.																			
104	Agr. College of Utah, Logan, Utah																			
105	University of Vermont, Burlington, Vt.																			
106	Norwich University, Northfield, Vt.																			
107	Virginia A. & M. Col., Blacksburg, Va.																			
108	Univ. of Virginia, Charlottesville, Va.																			
109	Washington & Lee Univ., Lexington, Va.																			
110	Washington Agr. Col., Pullman, Wash.																			
111	Univ. of Wash., Seattle, Wash.																			
112	West Virginia Univ., Morgantown, W. Va.																			
113	Univ. of Wisconsin, Madison, Wis.																			
114	Univ. of Wyoming, Laramie, Wyo.																			
115	Univ. of Sydney, Sydney, Australia																			
116	McGill University, Montreal, Canada				1					1				1						
117	School of Practical Science, Toronto, Can.	1				1				1				2						
118	University College, Sheffield, Eng.																			
	Totals in U. S.	10	5	55	93	85	63	66	1	363	5	1	2	386	12	5	6	4	3	3
	Totals Reported	11	5	55	94	86	63	66	1	365	5	1	2	389	12	5	6	4	3	3

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—The numbers at the left carry the names of the institutions forward through the tables.

NOTE 3.—The references are to the notes given on page 237.

TABLE IIa.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

			Chemistry.							Chemical Engineering.									Civil Engineering.											
		Grand Total.	Collegiate.						Grand Total.	Prep.	Collegiate.						Post Grad.	Grand Total.	Prep.	Short Course.			Collegiate.						Post Grad.	
	To.		Sp.	I	II	III	IV	To.		II	Sp.	I	II	III	IV	To.	I		II	I	II	III	Sp.	I	II	III	IV	To.	I	II
1																									a	13	7	20	1	
2																														
3																														
4																	1	1											1	
5																														
6																							14	25	26	15	11	91	5	
7																														
8																							53	z				53		
9																							8	23	10	5	3	44		
10																								10	7	12	9	38		
11																														
12																														
13																														
14																														
15																								11	5	7	6	29		
16																														
17																														
18																														
19																									20	8	2	30		
20											37	z				37		37					85	z				85		
21																														
22																							17	54	51	23	23	168	3	
23											1	27	8	8	2	41		41						80	15	8	3	56		
24													7	7	1	15	4	19						72	58	50	24	204	3	
25																														
26																														
27				5	3	5	3	16	16															11	10	6	5	32	1	
28																			36					60	38	18	6	122		
29																								21	7	11	4	43	2	
30																				1	11		4	21	8	10	2	45		
31										3	1	1		1	2	5		8	10				7	26	13	15	9	70	2	
32																														
33																														
34																								14	18	6	8	46		
35																														
36												4	1			5		5					2	6	1	4		13		
37																								28	29	22	15	94	2	
38																														
39																														
40												—	11	9	10	30		30						—	47	31	24	102		
41																							7	19	12	9	9	56		
42																							30	z				30		
43																														
44																														
45											15	z				15		15					96	z				96	2	
46																														
47												14	5	4	3	26		26						33	31	15	11	90		
48																														
49																								9	9	8	2	23		
50																							1	32	28	18	6	85	2	
51																														
52																										6		6		
53																														
54																			12				1	30	12	5	2	50		
55																														
56				1		4		5	5																					
57																											19	119	13	
58																														
59																														
60																														
61																							15	75	36	22	9	157		1
62																														
63																														
64											5	5	3	3	5	21	1	22					1	5	4	2	6	18		
65																							2	89	58	40	25	214		
66																							6	32	28	20	12	98		
67																														
68																							13	24	27	22	10	96	8	
69					1			1	1														12		5	1	3	21		

TABLE IIa—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

			Chemistry.							Chemical Engineering.									Civil Engineering.											
		Grand Total.	Collegiate.						Grand Total.	Prep.	Collegiate.						Post Grad.	Grand Total.	Prep.	Short Course.			Collegiate.						Post Grad.	
	To.		Sp.	I	II	III	IV	To.		II	Sp.	I	II	III	IV	To.	I		II	I	II	III	Sp.	I	II	III	IV	To.	I	II
70																														
71																								10	10	1	4	25		
72																				4			241	z				241		
73																														
74																														
75																														
76																														
77																							75					75	20	
78																														
79			1	7	16	12	6	42	42														13	17	10	11	7	58		
80	16	33									2	—	7	7	5	21		21						—	43	20	17	80		
81																														
82																														
83																														
84																														
85																														
86																							66	z				66		
87																														
88																														
89			8	8	13	9	13	51	51		6	7	3	4	2	22		22			2	2	13	23	17	15	12	80		
90																								68	41	24	17	150	1	1
91																								41	18	17	2	78	1	
92																														
93																											1	1	1	
94																							2	22	8	6	4	42		
95																														
96																														
97																														
98																														
99																														
100																							2	—	10	6	3	21		
101																														
102																														
103																							5	—	49	31	19	104		
104																														
105																								—	11	6	5	22		
106																														
107																								21	15	3	10	49	11	
108																														
109																								12	7	5	2	26		
110																							14		z			14		
111																														
112																							4	4	11	5	10	34		
113																								—	41	27	16	84		
114																														
115																								3	1	5		9		
116				1	3	6	2	12	12															9	8	6	6	29		
117																								34	26	9		69	3	
118																										1		1		
	16	33	9	21	33	30	22	115	115	3	67	58	45	38	30	238	6	247	58	5	13	2	804	978	904	604	404	3694	79	2
	16	33	9	22	36	36	24	127	127	3	67	58	45	38	30	238	6	247	58	5	13	2	804	1024	939	625	410	3802	82	2

NOTE 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

NOTE 2.—The numbers at the left carry the names of the institutions forward through the tables.

NOTE 3.—The references are to the notes given on page 237.

TABLE II*b*.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

			Electrical Engineering.												Ind. Arts and Mech. Arts.									Mechanical Engineering.						
	Post Grad.	Grand Total.	Prep.	Short Course.	Collegiate.							Post Grad.		Grand Total.	Prep.		Short Course.		Collegiate.				Grand Total.	Prep.		Collegiate.				
	III		II	II	Sp.	I	II	III	IV	V	To.	I	II		I	II	I	II	Sp.	I	II	To.		I	II	Sp.	I	II	III	IV
1		21					x																				a		26	24
2																														
3																														
4		1																												
5																														
6		96					x																			25	63	46	44	12
7																														
8		53			45	z					45			45												32	z			
9		44			3	27	13	11	5		59			59																
10		38																									18	12	10	4
11																														
12																														
13																														
14																														
15		29				12	8	0	2		22			22												2	1	4	1	0
16																														
17																														
18																														
19		30																												
20		85			85	z					85			85												85	z			
21																														
22		171			15	48	31	10	7		111	1		112												15	45	29	20	22
23		56			3	75	28	18	16		140			140												4	37	27	11	8
24		207				118	80	41	30		269	4		273													104	110	58	39
25																														
26																														
27		33				29	11	14	5		59			59													16	11	17	6
28		158	45			92	66	26	6		190			235											52		44	25	16	7
29		45				4	2	1	0		7			7																
30		57																												
31		82	14		6	20	8	11	10		55	2		71											8	4	4	3	3	2
32							x		3		3			3			67						67				—	47	24	3
33																														
34		46					x																				54	30	29	23
35																														
36		13					x					1		1												24	41	18	8	15
37		96				40	16	6	17		79			79													9	11	2	7
38																														
39																														
40		102				—	39	26	31		96			96													—	54	34	41
41		56			13	19	8	6	3		49			49												18	20	20	14	10
42		30			50	z					50			50												2	z			
43																														
44																								72			75	35	46	21
45		98			43	z					43			43												96		z		
46																														
47		90				55	30	13	6		104			104													37	32	5	11
48																														
49		23						3			3			3																
50		87			1	26	18	10	3		58	4		62												1	9	10	9	5
51																														
52		6						3	2		5			5																1
53																														
54		62	14			41	24	18	6		89			103	24	15							39		7		13	2	4	1
55																														
56						8	4	2			14			14													12	6	4	2
57		132																												
58																														
59																								229		24	74	69	48	54
60																														
61		158										2	3	5																
62																														
63																														
64		18			3	10	6	8	3		30	2		32												1	5	2	2	
65	4	218			122		x			t	122			122												633				
66		98			1	36	35	22	22		116		2	118												2	35	28	28	18
67																														
68		104																												
69		21			2		5	3	5		15			15					3			3	3			5		1		5

Table IIb.—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

			Electrical Engineering.												Ind. Arts and Mech. Arts.									Mechanical Engineering.						
	Post Grad.	Grand Total.	Prep.	Short Course.	Collegiate.							Post Grad.		Grand Total.	Prep.		Short Course.		Collegiate.				Grand Total.	Prep.		Collegiate.				
	III		II	II	Sp.	I	II	III	IV	V	To.	I	II		I	II	I	II	Sp.	I	II	To.		I	II	Sp.	I	II	III	IV
70																														
71		25				20	20	16	6		62			62													11	5		
72		245																												
73																														
74																														
75																														
76																									10	3	13			
77		95			37						37	6		43																
78																														
79		58			14	17	16	15	4		66			66												10	40	33	17	17
80		80				—	44	11	9		64			64			17	6		—	1	1	24			1	—	27	27	16
81																														
82																														
83																														
84																														
85																														
86		66			41	z					41			41																
87																										2	9	9	2	7
88																														
89		84					x	8	3		11			11												6	47	40	10	6
90	1	153			3	56	27	16	9		111			111												4	80	41	33	7
91		79			3	71	27	25	9		135	1		136			2						2			1	50	27	20	9
92																														
93		2				—	3	6	1		10			10															3	3
94		42																								9	12	10	5	1
95																														
96																														
97																														
98																														
99																														
100		21																									—	3	4	2
101																														
102																														
103		104																								6	—	43	20	10
104																														
105		22				—	11	2	8		21			21													—	4	5	4
106																														
107		60				52	41	14	15		122			122						9	7	16	16				49	30	14	20
108																														
109		26																												
110		14																								32		z		
111																														
112		34																								2	3	2	5	6
113		84				—	25	15	16		56			56													—	47	35	19
114																10			10			10	20							
115		9								x																	5	5	1	0
116		29				23	19	16	12		70			70													11	11	5	6
117		72								x																	74	35	21	—
118		1		1	26	—	12	3			41			42													39	8	3	
	5	3858	73	0	490	876	646	380	262		2654	23	5	2755		49	86	6	13	9	8	30	171		378	1049	1030	953	663	468
	5	3969	73	1	516	899	677	399	274		2765	23	5	2867		49	86	6	13	9	8	30	171		378	1049	1159	1012	693	474

Note 1.—Where a column necessary to complete the symmetry of the report has been omitted it means that no institution has used that column in its report.

Note 2.—The numbers at the left carry the names of the institutions forward through the tables.

Note 3.—The references are to the notes given on page 237.

TABLE IIc.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	Mechanical Eng.						Metallurgical Engineering.										Mining Engineering.											
	Collegiate.		Post Grad.			Grand Total.	Collegiate.						Post Grad.			Grand Total.	Prep.	Short Course.		Collegiate.						Post Grad.		Grand Total.
	V	To.	I	II	III		Sp.	I	II	III	IV	To.	I	II	III		II	I	II	Sp.	I	II	III	IV	To.	I	II	
1		50	3		x	53																						
2																												
3																												
4																		2	2	5	11	7	7	6	36			40
5																												
6		190			x	190						y								48	73	y 44	55	28	248	2	2	252
7																												
8		32				32														85	z				85	4		89
9																												
10		44			4	48																						
11																					121	54	44	25	244			244
12																												
13																												
14																												
15		8				8																						
16																												
17																												
18																												
19																												
20		85				85																						
21																												
22		131	14			145																						
23		87				87																						
24		311	14			325																						
25																												
26																												
27		50	1			51																						
28		92				144											3				7	3	3	1	14			17
29																						2	2		4	1		5
30																												
31		16				24											1			2	9	4	4	1	20			21
32		74	1			75																						
33																												
34		136	1			137																						
35																												
36	x	106	1			107																						
37		29				29																						
38																												
39																												
40		129				129															—	27	35	14	76			76
41		82				82				y										15	23	y 18	9	7	67			67
42		2				2																						
43																												
44		177				249																						
45		96	3			99																						
46																					73	69	35	f	177	5		182
47		85				85															59	29	17	4	109			109
48																												
49																							1		1			1
50		34				34																						
51																												
52		1				1																						
53																												
54		20				27																						
55																												
56		24				24																						
57																												
58																												
59		269				498																						
60																												
61																												
62																												
63																												
64		10				10																						
65	t	633	20			653																						
66		111		1	1	113	2	2	3	2	1	10		1	2	13				11	47	43	33	18	152		3	155
67																												
68																												
69		11				11																						

TABLE IIc.—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	Mech. Eng.						Metallurgical Engineering.										Mining Engineering.											
	Collegiate.		Post Grad.			Grand Total.	Collegiate.						Post Grad.			Grand Total.	Prep.	Short Course.		Collegiate.						Post Grad.		Grand Total.
	V	To.	I	II	III		Sp.	I	II	III	IV	To.	I	II	III		II	I	II	Sp.	I	II	III	IV	To.	I	II	
70	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
71	...	16	...	...	...	16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
72	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
73	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
74	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
76	...	16	...	...	...	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	1
77	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
78	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
79	...	117	...	...	...	117	...	...	...	...	...	...	...	...	...	...	...	...	...	9	19	15	15	11	69	...	...	69
80	...	71	...	...	...	71	...	...	...	...	...	...	...	...	...	...	...	11	2	1	—	18	10	7	36	...	...	49
81	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
82	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
83	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
84	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
85	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
86	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17	z	...	...	...	17	...	...	17
87	...	29	...	...	...	29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
88	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
89	2	111	...	...	...	111	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
90	...	165	...	...	1	166	...	7	2	1	3	13	...	...	...	13	...	...	...	2	20	8	5	6	41	...	...	41
91	...	107	1	...	...	108	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	7	4	...	20	...	...	20
92	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
93	...	6	...	...	...	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
94	...	37	...	...	...	37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
95	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
96	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
97	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
98	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
99	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
100	...	9	...	...	...	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
101	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
102	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
103	...	79	1	...	...	80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
104	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
105	...	13	...	...	...	13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
106	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
107	...	113	10	...	...	123	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
108	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
109	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
110	...	32	...	...	...	32	...	...	...	...	...	...	...	...	...	...	...	...	...	24	z	...	...	...	24	...	...	24
111	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
112	...	18	...	...	...	18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
113	...	101	...	...	...	101	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
114	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12	...	...	12	...	...	...	...	12	...	...	24
115	x	11	...	...	...	11	...	...	...	y	...	...	...	...	...	...	...	...	...	...	34	29	19	y	82	...	...	82
116	...	33	...	...	...	33	...	...	...	y	...	...	...	...	...	...	...	...	...	...	23	29	19	y 7	78	...	...	78
117	x	130	10	...	...	140	...	...	...	...	...	...	...	...	...	...	...	...	...	...	37	18	14	—	69	1	...	70
118	...	50	...	...	...	50	3	16	9	...	...	28	2	...	...	30	...	...	...	...	5	2	...	...	7	...	...	7
	2	4165	70	1	6	4620	2	9	5	3	4	23	...	1	2	26	16	13	4	231	472	343	279	128	1453	12	5	1503
	2	4389	80	1	6	4854	5	25	14	3	4	51	2	1	2	56	16	13	4	231	571	421	331	135	1689	13	5	1740

NOTE 1.—Columns are omitted which were not used in the reports.
NOTE 2.—The numbers at the left carry the names of the institutions forward through the tables.
NOTE 3.—The references are to the notes given on page 237.

TABLE II*d*.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	Municipal Eng.					Naval Architecture.							Sanitary Eng.					Special.								
	Collegiate.			Post Grad.	Grand Total.	Collegiate.						Grand Total.	Collegiate.				Grand Total.	Prep.		Short Course.	Collegiate.					
	I	IV	To.	I		Sp.	II	III	IV	V	To.		II	III	IV	To.		I	II	I	Sp.	I	II	III	IV	To.
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																					18					18
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20																				25	115	n				115
21																										
22	1	2	3	1	4																					
23																		330								
24																						3				3
25																										
26																										
27																										
28																										
29																										
30																										
31																										
32																					19					16
33																										
34																										
35																										
36																					11	10		1	e	22
37																						3	2	2		7
38																										
39																										
40							13	16	10		39	39	2	5	7	14	14				w	440	134	142	93	809
41																										
42																		7			5	z				5
43																										
44																										
45						1	z			q	1	1									233	w				233
46																										
47																					27					27
48																										
49																										
50																					176					176
51																										
52																					2	5	5	g		12
53																										
54																					3					3
55																										
56																					9					9
57																										
58																										
59																										
60																										
61																										
62																			20		8	z				8
63																										
64																					3					3
65						37				t	37	37														
66																										
67																										
68																										
69																					3	10	w			13

TABLE IId.—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	Municipal Eng.					Naval Architecture.							Sanitary Eng.					Special.								
	Collegiate.				Grand Total.	Collegiate.						Grand Total.	Collegiate.				Grand Total.	Prep.		Short Course.	Collegiate.					
	I	IV	To.	I		Sp.	II	III	IV	V	To.		II	III	V	To.		I	II		Sp.	I	II	III	IV	To.
70																					75	z				75
71																										
72																										
73																										
74																										
75																										
76																										
77																										
78																										
79																										
80																					19	216	w			235
81																										
82																										
83																										
84																										
85																										
86																										
87																										
88																										
89																						7	7			14
90																					2					2
91																										
92																										
93																										
94																										
95																										
96																										
97																										
98																										
99																										
100																						15	w			15
101																										
102																										
103																						44	w			44
104																										
105																						27	w			27
106																										
107																										
108																										
109																										
110																										
111																										
112																		17 16	14 13							
113																					38	218	3	4	2	265
114																										
115																										
116																		25								
117																										
118																										
	1	2	3	1	4	38	13	16	10		77	77	2	5	7	14	14	417		25	766	998	151	149	95	2159
	1	2	3	1	4	38	13	16	10		77	77	2	5	7	14	14	442		25	766	998	151	149	95	2159

NOTE 1.—Columns are omitted which were not used in the reports.
NOTE 2.—The numbers at the left carry the names of the institutions forward through the tables.
NOTE 3.—The references are to the notes given on page 237.

TABLE IIe.

Enrollments by Departments and Classes in the Different Engineering Colleges of the United States for the Year 1901–1902.

	Spec.			Total.																
	Post Grad.		Grand Total.	Prep.		Short Course.			Collegiate.							Post Grad.			Grand Total.	
	I	III		I	II	I	II	III	Sp.	I	II	III	IV	V	To.	I	II	III		
1										—	—	39	31		70	4			74	a
2																				
3																				
4						2	2		5	11	7	7	6		36	2			42	
5																				
6									87	161	116	114	51		529	7	2		538	b
7																				
8									215	z					215	4			219	u
9									6	50	23	16	8		103				103	
10			18						18	31	24	23	13		109			4	113	
11										121	54	44	25		244				244	
12																				
13																				
14																				
15									2	24	17	8	8		59				59	
16																				
17																				
18																				
19										—	20	8	2		30				30	
20			140			25			407	z					407				432	n
21																				
22									51	173	123	63	65		475	23			498	o
23			330	330					27	175	80	40	29		351				681	
24			3							297	255	156	94		802	25			827	
25																				
26																				
27										63	38	43	20		164	2			166	p
28					136					203	132	63	20		418				554	
29										25	11	14	4		54	3			57	
30						1	11		4	21	8	10	2		45				57	
31					36				20	60	28	34	24		166	4			206	c
32			19			67			19	—	47	24	6		96	1			164	d
33																				
34										68	48	35	31		182	1			183	
35																				
36			22						37	61	20	13	17		148	2			150	e
37			7							80	58	32	39		209	2			211	
38																				
39																				
40	9		818							440	341	308	246		1335	9			1344	
41									63	86	60	41	33		283				283	
42			12	7					87	z					87				94	
43																				
44				72						75	35	46	21		177				249	
45			233						484	z					484	5			489	q
46										73	69	35			177	5			182	f
47		r	27						27	198	127	54	35		441				441	r
48																				
49										9	9	7	2		27				27	
50	7	s	183						179	67	56	37	14		353	13			366	s
51																				
52			12						2	5	5	9	3		24				24	g
53																				
54			3	24	48				4	84	38	27	9		162				234	
55																				
56			9						9	21	10	10	2		52				52	
57													19		19	i 13			32	i
58																				
59				229					24	74	69	48	54		269				498	
60																				
61									15	75	36	22	9		157	2	4		163	
62			28	20					8	z					8				28	
63																				
64			3						14	25	15	15	14		83	3			86	
65									799	106	68	48	35		1056	20		6	1082	t
66									34	181	153	118	86		572		8	3	583	
67																				
68									13	24	27	22	10		96	8			104	
69			13						25	10	12	4	13		64				64	

TABLE IIe.—*Continued.*

Enrollments by Departments and Classes in the Different Engineering Colleges in the United States for the Year 1901-1902.

	Spec.			Total.																
	Post Grad.		Grand Total.	Prep.		Short Course.			Collegiate.							Post Grad.			Grand Total.	
	I	III		I	II	I	II	III	Sp.	I	II	III	IV	V	To.	I	II	III		
70			75						75						75				.75	
71										41	35	17	10		103				103	
72						4			241	z					241				245	
73																				
74																				
75																				
76					10				3	14					17				27	
77									115						115	27			142	
78																				
79									47	100	91	70	46		354				354	
80			235			40	13		29	216	149	81	57		532				585	
81																				
82																				
83																				
84																				
85																				
86									124	z					124				124	
87									2	9	9	2	7		29				29	
88																				
89			14			10	7	2	34	98	90	60	42	3	327				346	
90			2						11	231	119	79	42		482	1	1	2	486	
91						2			4	171	79	66	20		340	3			345	
92																				
93											3	9	5		17	1			18	
94									11	34	18	11	5		79				79	
95																				
96																				
97																				
98																				
99																				
100			15						2	15	13	10	5		45				45	
101																				
102																				
103			44						11	44	92	51	29		227	1			228	
104																				
105			27							27	26	13	17		83				83	
106																				
107										131	93	31	45		300	21			321	
108																				
109										12	7	5	2		26				26	
110									70	z					70				70	
111																				
112			60	17,16	14 13				6	7	13	10	16		52				112	m
113	7	v	272						38	218	116	81	53		506	7			513	
114					22				22						22				44	
115										42	35	25	0		102				102	
116	3		28	25						68	70	52	33		223	3			251	
117						1				145	80	44	—		269	14			284	
118							1		29	60	31	7	—		127	2			130	
	23		2624	994		151	33	2	3530	4545	3192	2233	1501	3	15004	219	15	15	16433	
	26		2652	1019		152	34	2	3559	4860	3408	2361	1534	3	15725	238	15	15	17200	

NOTE 1.—Columns are omitted which were not used in the reports.
NOTE 2.—The numbers at the left carry the names of the institutions forward through the tables.
NOTE 3.—The references are to the notes given on page 237.

HENRY FULTON,

Died December 6, 1901.*

Henry Fulton was born March 14, 1847, near Rochester, New York. In 1862, when only fifteen years old, he entered the Union service as a cavalryman and served throughout the war. In a charge through a narrow cut while attempting to capture one of Early's wagon trains, his horse was shot and fell on him, resulting in an injury to his leg which troubled him through the rest of his life. He was taken from a pile of dead and wounded and sent to Libby Prison where he spent four months. At the end of this time he was exchanged, being considered unfit for further service. At the close of the war, his term of enlistment being unexpired, he was sent West against the Indians. He was mustered out of the service with the rank of Major in 1870 in Colorado, where he spent some time in lime-burning for the Government and in mining. During the years preceding 1881 he was engaged in engineering work at Willett's Point and in Brooklyn. An excellent map of the City of Brooklyn was produced during this period. In the summer of 1881 he again came to Colorado and engaged in mining at Ward and Georgetown until 1886.

Mr. Fulton entered the University of Colorado in 1887 and received his Bachelor's degree in 1891 and his Master's degree in 1893. After a course of study at the University of Michigan he was made Professor of Civil Engineering in the Colorado School of Applied Science and was later made Dean of the School, which positions he held at the time of his death in December, 1901. He was a member of the Society for the Promotion of Engineering Education since 1894, had been President of the Colorado School-Masters' Club, and Chairman of the High School and College Section of the State Teachers' Association. Professor Fulton was well versed in history, in economics, in literature; he was trained in athletics, in business, in statescraft, and he was also active in many allied educational movements. The following is a quotation from an article by Dr. Charles S. Palmer: "His muscular figure, his genial countenance, his commanding presence, his keen mind, his superb common sense, his ever-youthful spirit, his never-sleeping interest, his constant friendship—his was a many-sided manifestation of one great, consistent character, and every syllable of that character was accented. Professor Fulton's influence was powerful, not only in the daily execution of his departmental duties, not only in the articulation of the many general university interests, but also in a thousand hidden ways where his large clientage of influential friends adjusted many a difficulty and solved many a problem, as the well-meant endeavors of his living colleagues can never do.

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* Memoir prepared by Dean George H. Rowe.

"As we sympathize with his family, as we struggle for ourselves to recover from the soreness of this fresh blow, as we go on to study and work for the university of this commonwealth—we are thankful that we have known this great man. He has helped us—he has left us; but he has left with us the heritage of a plain, honest devotion."

JOHN BUTLER JOHNSON,

Died June 23, 1902.*

By the accidental death of Professor J. B. Johnson this Society has lost one of its most active and valued members, and a host of engineers and teachers a personal friend. Professor Johnson was born in 1850 on a farm near Milboro, Clark Co., Ohio. In 1866 the family moved to Kokomo, Ind., where he attended Howard College for a short time, and then went to the Holbrook Normal School at Lebanon, Ohio. He afterwards taught country schools for some time and later became principal of the high school at Kokomo. From 1872 to 1874 he was Secretary of the Indianapolis School Board. In the latter year he entered the University of Michigan and graduated in 1878 from the civil engineering course. He gained some professional experience during his school course and, after graduating, was engaged on the Great Lake Survey until 1881. From 1881 to 1883 he was assistant engineer on the Mississippi River Commission and while on this work he carried out important flood measurements and made some valuable contributions relating to the regulation of the river.

In 1883 he became Professor of Civil Engineering at Washington University, St. Louis, where he remained for sixteen years.

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* Memoir prepared by Professor Frederick E. Turneaure.

During this time he gained a world-wide reputation by his valuable contributions to engineering literature and his active work in connection with engineering and other societies. It was while here, also, that he carried out an extensive series of timber tests for the United States Government.

In 1899 he was made Dean of the College of Engineering of the University of Wisconsin. He entered upon his new work with great vigor and enthusiasm, and during his brief administration of about three years achieved great success. In this time the number of students in engineering increased from 240 to over 500, a new engineering building was constructed, the equipment largely increased, and the influence of the college greatly extended.

Professor Johnson was a man of wide sympathies and very broad interests. He was a successful engineer, an educator in the largest sense, and an enthusiastic teacher in the class-room. He was also deeply interested in all that contributed to the welfare of society and did more than his share in social and religious affairs. He was a member of many engineering and other societies and in all his activity and helpfulness were almost remarkable. He was largely instrumental in the founding of this Society and of all the organizations with which he was connected this one seemingly held the first place in his heart. The work of his committee on behalf of industrial education was one of the most important results which have followed from the organization of the Society.

Professor Johnson was one of the most successful of writers of engineering text-books and his well-known works have made his name famous throughout the engineering world.

His most prominent personal traits were, perhaps, his activity and enthusiasm in his own work, and his encouraging sympathy in the work of others; and no one will feel his loss more keenly than his own students and the younger generation of engineers, to whom he was an inspiration and guide.

RODNEY G. KIMBALL,

Died April 25, 1800.*

Rodney G. Kimball, A.M., Ph.D., Professor of Applied Mathematics and Engineering at the Polytechnic Institute of Brooklyn, N. Y., died on Wednesday, April 25, 1900.

During the last year of his life he was in feeble health, but somewhat strengthened by his summer's rest he returned to the Polytechnic at the opening of the college year, much to the gratification of his students with whom he was a favorite. It soon became evident that his strength was failing. Nevertheless he conscientiously strove to discharge his class-room duties; and even continued to direct his students in their work after his failing health forced him to be absent.

In the death of Professor Kimball we lose one of the most kind-hearted of men and the best of instructors. Unselfish and sympathetic in nature, yet with a high sense of duty, fearless, conscientious and just in all his dealings, he won the implicit trust of all who knew him.

Professor Kimball was born in New York City in 1835; he graduated from New York college with a degree of A.B. in 1854, subsequently the degree of A.M. was conferred upon him, and later Hamilton College honored him with a degree of Ph.D.

He became assistant to the Professor of Mathematics in the State Normal School at Albany in 1855, after a year's practical experience in railroad engineering since graduating from college. He became professor in the same institution in 1859. In 1869 he was offered charge of the Department of Applied Mathematics and Engineering at the Polytechnic Institute, which position he so satisfactorily filled up to the time of his death. During these thirty-one years of service he had charge of the greater part of the work in civil engineering, astronomy and steam engineering.

In answer to the call for "more men" which came after our army was defeated in the seven days' battle before Richmond in 1862, Professor Kimball, together with his assistant, Albert N. Husted, organized a company at the State Normal School, resigned their positions and joined our army in the field. The record of the services of this company, of which Professor Kimball was appointed Captain, in the 44th Regiment of New York, is one which professional teachers may point to with pride. In the battle of Fredericksburg Professor Kimball was subjected to exposure which brought on serious illness and undoubtedly planted the seeds of disease which finally terminated his life in the maturity of his power and usefulness.

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* Memoir prepared by Arthur L. Williston.

Professor Kimball was associated with the late Professor Davies, of Columbia University, in editing "Davies' Surveying," a book primarily issued for the use of the West Point cadets, but now in wide-spread use. He always took a deep interest in the Society for the Promotion of Engineering Education; and though he was not always able to attend its meetings, he was thoroughly familiar with all its transactions and delighted to see it prosper.

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